INFLUENCES OF THE BUILT ENVIRONMENT ON SEDENTARY BEHAVIOR IN THE WORKPLACE

A Thesis

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by

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ABSTRACT

Given the links between sedentary behavior and health, this study examines the relationships between office workers' objectively measured sedentary behavior patterns, several workplace spatial characteristics, presenteeism (the extent to which health conditions adversely affect at-work productivity), and levels of environmental satisfaction. Several significant links were identified between workplace spatial characteristics and sedentary behavior at work, with the most significant being self-reported distance from coffee/break area and the Space Syntax measure of connectivity. The evidence collected was used to inform design suggestions to encourage more active work styles for office workers.

BIOGRAPHICAL SKETCH

William (Carlos) Higgins is an alumnus of the Department of Design and Environmental Analysis '14, where he followed the Facility Planning and Management track. Knowing how well DEA's pedagogical style aligned with his own interests, Carlos decided to pursue his Masters in the department through the '4+1' program – this time pursuing a Masters in Human Environment Relations with a concentration in Sustainable Design Studies. Carlos' interests lie in the human dimensions of sustainable design, and particularly how sustainable building features affect end-users' perceptions of indoor environments. His previous research has included Post-Occupancy Evaluations (POE's) of LEED-certified buildings on Cornell's Campus.

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This research would not have been possible without the help of Mary-Lynn Cummings, the Director of Space Planning for Cornell University. Ms. Cummings' help in acquiring approval for the study, obtaining the list of building occupants, and obtaining building floorplans was vital to this study.

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Abstract:

Purpose: Spatial environments influence human behavior both directly and indirectly. Given the links between sedentary behavior and health, this study examines the relationships between office workers' objectively measured sedentary behavior patterns, several workplace spatial characteristics, presenteeism (the extent to which health conditions adversely affect at-work productivity), and levels of environmental satisfaction.

Methods: This study used a multiple-tool methodology. The spatial variables include objectively measured and self-reported distances from individual workstation (office or cubicle) to shared service and amenity spaces and the Space Syntax measures of connectivity and integration. Sedentary behavior was measured objectively using the ActiGraph GT3X+ accelerometer, and presenteeism was measured by the Work Limitations Questionnaire. Levels of environmental satisfaction were measured using the Workplace Environmental Satisfaction Survey.

Results: Several significant links were identified between workplace spatial characteristics and sedentary behavior at work. The average length of a sedentary period was negatively associated with self-reported distance from coffee/break area. Breaks in sedentary time were positively associated with self-reported distance from printer/copier. Average amount of time spent in sedentary behavior was negatively associated with connectivity, objective distance from printer/copier, self-reported distance from mail room, and self-reported distance from coffee/break area. Percent of workday time spent being sedentary was negatively associated with connectivity and self-reported distance from printer/copier and break area. Amount of time spent in light physical activity was positively associated with connectivity and self-report

distance to printer/copier and break area. Amount of time spent in moderate physical activity was positively associated with connectivity, objectively measured distance from restroom, printer/copier, and coffee/break area, and with self-reported distance from mail room and coffee/break area. The only finding regarding presenteeism is a positive association with percent time spent in vigorous physical activity. In a regression model, connectivity and self-reported distance from coffee/break area were the most significant predictors of sedentary time.

Conclusions: The evidence collected was used to inform design suggestions to encourage more active work styles for office workers. The main spatial environment characteristics that influence sedentary behavior and physical activity patterns at work are the space syntax measure of connectivity of floorplan, self-reported distance between workstation and meeting space area, distance between workstation and printer/copier, and distance between workspace and coffee/break area. In regression models, connectivity and distance from meeting room (both objective and self-report) were found to have significant effects on percent of time spent sedentary, controlling for job position.

These results suggest that care should be taken when designing layouts to increase the connectivity of workspaces, for example by removing or reducing the height of partitions in cubicle workspaces, when the type of work being performed allows it. In order to encourage individuals to reduce the length of their sedentary periods and reduce the overall amount of time spent sedentary, it is recommended that instead of distributing amenity spaces (e.g. one small coffee area for each of several suites on a floor), these spaces should be located in centralized areas, common to several independent suites and perhaps even floors.

CHAPTER 1: INTRODUCTION

As Dudgil et al (2008) point out, “Every year, physical inactivity is estimated to cause 600,000 deaths in the EU region (about 6 per cent of the total).” Further, some recent studies have suggested that “Physical inactivity may theoretically be responsible for twice as many total deaths as high BMI (>30) in this [European] population” (Ekelund et al., 2015), making sedentary research a public health priority.

Several studies have identified the specific negative physiological effects of sedentary behavior, leading Duncan et al (2013) to conclude, “Prolonged and uninterrupted sitting is increasingly recognized as a risk factor for ill health.”

> *“[I]t is imperative to limit the volume of sitting in populations that engage in high levels of sitting to improve the health of these populations. White collar and professional occupation groups currently engage in high levels of occupational sitting and the high level of sitting is likely a function of the social and environmental characteristics of the workplaces these groups occupy. Thus, it is important to understand how these factors influence sitting within the office environment and to do so within behaviour and setting-specific Ecological Models” (Duncan et al, 2013).*

This thesis is an effort as such, seeking to understand the workplace spatial correlates of sedentary behavior pattern in a working adult population.

Previous studies have found that between 50-80% of employees’ time at work is spent sitting (Owen et al, 2010; Evans et al, 2012; Chau et al, 2010; Hua & Yang, 2012; Stephens et al, 2014; Brown et al, 2013) with estimates of average total sitting time at work ranging from 237 minutes (Jans, Proper, & Hildebrandt, 2007) to 337 minutes (Gilson et al, 2009) to 382 minutes

(Duncan et al, 2013) per day. Evans et al (2012) found that a majority of this time (51%) is accumulated in periods longer than 30 minutes.

Schuna, Johnson, & Tudor-Locke (2013), in a study of U.S. adults, found that individuals who report higher levels of moderate to vigorous physical activity (MVPA) do not necessarily engage in less sedentary time than those who report lower levels of activity. This means that individuals who are meeting general guidelines for physical activity can still be at risk of the negative physiological effects related to sedentary behavior – regardless of their meeting physical activity requirements. It has also been shown that sedentary workers do not compensate for long periods of sitting at work by reducing sedentary behavior outside of work (Jans, Proper, & Hildebrandt, 2007). Therefore, strategies, policies and/or structural changes are needed to encourage individuals to reduce prolonged sitting in the workplace.

Research into sedentary behavior is critical at this point in time, because, as Hamilton et al (2008) report "Given this new understanding of inactivity physiology and the health impacts of sedentary behavior, we would argue that there is now sufficient evidence for health practitioners and public health experts to expand their thinking beyond "purposeful exercise" and give serious consideration to officially recommending reductions in sedentary behaviors."

However, as Marshall & Ramirez (2011) insightfully point out: "Despite the growing…evidence base of the deleterious effects of prolonged sitting time on health, data on modifiable correlates of sitting time among adults are virtually nonexistent", and Chau et al (2010) echoed this sentiment, claiming "Currently, there is a dearth of evidence on the effectiveness of workplace interventions for reducing sitting."

In order to address the issue of how workplace spatial characteristics influence sedentary behavior we need to rethink the structure of the work environment. This research addresses this gap in the scientific literature by providing insight into the spatial correlates of sedentary behavior in the workplace context, considering that physical environment correlates might be better suited for targeted intervention efforts than sociodemographic or other variables that have been shown to be associated with sedentary time (Rhodes, Mark, and Temmel, 2012). The current study examines the relationships between selected spatial features (those that have previously been identified as possible correlates of sedentary behavior in the office context) with objectively measured sedentary time and employee presenteeism.

The inclusion of measures of employee presenteeism in this study provides insight into the ways in which sedentary behaviors affect certain measures of self-reported employee productivity. “Employee presenteeism, a relatively new concept, is the extent to which physical or psychosocial symptoms or conditions adversely affect the work productivity of individuals who choose to remain at work. Conceptualizations of presenteeism indicate that it is not simply the opposite of absenteeism, but rather, a reduced ability to work productively. A recent policy paper indicated that the costs of presenteeism are between 1.9 and 5.1 times more than those incurred for absenteeism. These costs are associated with reduced work output, errors on the job, and failure to meet company standards.” (Brown et al, 2013)

This research intends to inform future intervention studies, as well as future building designs, that can hopefully help to reduce sedentary time in the workplace, and consequently improve the health of office employees and support their work performance.

CHAPTER 2: LITERATURE REVIEW

2.1 Physiology

In a meta-analysis of the literature on sedentary behavior, Thorp et al (2011) found significant associations between sedentary behavior and increased incidence of cardiovascular disease; symptomatic gallstone disease; and mental disorders; consistent relationships were found between high levels of sedentary behavior and increased risk for obesity; mortality; weight gain from childhood to adulthood; increased risk for diabetes; and site-specific cancers; including ovarian, colon, and endometrial cancer (Thorp et al, 2011). Dunstan, Thorp, and Healy (2011) found that sedentary time is associated with waist circumference, blood glucose, insulin, and triglycerides. Seguin et al (2014) found that, in an ethnically diverse sample of 92,234 women aged 50-79, women who reported the highest sedentary time had an increased risk of all-cause mortality compared to the women who reported the least sedentary time. The relationships between sedentary time and mortality risk were sustained after controlling for multiple potential confounders, including levels of physical activity, physical function, and chronic disease status, among other relevant factors (Seguin et al, 2014).

> *"Physiologically, it has been suggested that the loss of local contractile stimulation induced through sitting leads to both the suppression of skeletal muscle lipoprotein lipase (LPL) activity (which is necessary for triglyceride uptake and HDL- cholesterol production) and reduced glucose uptake" (Owen et al, 2010).*

2.1.1 Total Sitting Time and Prolonged Uninterrupted Sitting

Both the total amount of sedentary time and the length of each sedentary period are important factors in understanding the physiological effects of sedentary behavior.

> *"Total sedentary time..is detrimentally associated with several cardiovascular risk factors, whereas breaking up sedentary time (independent of total sedentary time and moderate-to-vigorous intensity activity) is beneficially associated…. adults who interrupted their sedentary time more frequently (breaks in sedentary time) had a better cardiometabolic profile than those whose sedentary time was mostly uninterrupted….independent of total sedentary time and time spent in moderate-to-vigorous intensity physical activity" (Dunstan, Thorp, & Healy, 2011).*

Further, it has been shown that a two-minute break from sitting (walking) can have positive effects on glucose metabolism, therefore reducing cardiovascular risk (Dunstan et al, 2011). Attempts to influence sedentary behavior should therefore address not only reductions in overall sedentary time, but should also aim to increase the number of breaks in sedentary time, therefore reducing the amount of time spent in prolonged sitting periods. This is critical for it has been shown that breaks in sedentary time - as distinct from the overall volume of time spent being sedentary - have beneficial associations with metabolic biomarkers (Owen et al, 2010).

2.1.2 The Relationship Between Sedentary Behavior and Physical Activity

In a study by Owen et al (2010) it was found that too much sitting is distinct from too little exercise, and that each has distinct (although overlapping) physiological effects. The emerging field of inactivity physiology has shown that sedentary behavior "influences disease risk via pathogenic processes that are sometimes different from the molecular and physiological responses associated with PA and exercise"(Marshall & Ramirez, 2011).

In a review of recent research, Dunstan, Thorp, and Healy (2011) found that associations between sedentary behaviors and all-cause and cardiovascular disease mortality risk persisted following adjustment for physical activity, suggesting that physical activity did not mitigate the negative physiological effects of sedentary behavior.

This poses an interesting problem, for sedentary behavior is at once an issue intimately related to yet independent of physical activity; sedentary behavior can indeed not be equated with a lack of physical activity. In some cases there is the phenomenon of the 'active couch potato' – an individual who meets recommended physical activity guidelines but still engages in high levels of sedentary behavior. The deleterious effects of sedentary behavior are not balanced out, so to say, by participating in even large amounts of physical activity.

This suggests that in order to address many of the physiological health issues associated with sedentary behavior and physical activity, it is not sufficient to exclusively encourage increases in physical activity; instead sedentary behavior and physical activity patterns should be addressed simultaneously.

While there is some promising research evaluating workplace interventions to increase physical activity, Gilson et al (2009) suggest that interventions designed to increase workplace physical activity do not automatically reduce high volumes of sitting, even when effective at increasing physical activity. Thus, sedentary behavior may require different interventions than physical activity interventions, based on different correlates.

This research works to inform future intervention studies to decrease the amount of time spent in sedentary behaviors.

2.2 Physical Activity Interventions

A study by Ekelund et al. (2015) "suggests that efforts to encourage even small increases in activity in inactive individuals may be beneficial to public health." Accordingly, Zimring et al. (2005) write "It has been suggested that 2 minutes of additional stair climbing per day would result in weight reduction of >1.2 pounds per year"

Several studies have reported on the efficacy of workplace physical activity interventions at increasing the level of physical activity of workers. Here we must be cognizant of the fact that interventions designed to increase workplace physical activity do not automatically reduce high volumes of sitting, even when effective at increasing physical activity. These interventions are detailed for the purpose of understanding the ways that occupant behavior can be affected, as this can provide insight into the interventions that might be effective at impacting sedentary behavior patterns. There are two general types of interventions will be discussed: those based on spatial characteristics, and those not based on spatial characteristics. Most interventions to date are not spatial in nature, however spatial characteristics have also been shown to have an effect on occupants.

2.2.1 Non-Spatial Physical Activity Interventions

Marshall (2004) reported “The greatest potential for influencing the overall workforce appeared to be programs that included less 'organized' approaches and promoted incidental PA within and around the workplace.”

Dudgil et al (2008) reported several successful interventions to increase physical activity in the workplace, including: workplace walking interventions using pedometers when accompanied by a) facilitated goal setting (Chan et al., 2004; Thomas and Williams, 2006) b) diaries and self monitoring (Chan et al., 2004; Murphy et al., 2006; Thomas and Williams, 2006) or c) walking routes (Gilson et al., 2007). Four studies (Talvi et al., 1999; Proper et al., 2003a,b,c,d; Aittasalo et al., 2004; Osteras and Hammer, 2006) reported that workplace counseling influenced physical activity behavior. Although a further review by Conn et al (2009) found significant heterogeneity within the findings, significantly positive effects were observed for physical activity behavior; fitness; lipids; anthropometric measures; work attendance; and job stress.

Plotnikoff et al (2005) found that workplace e-mail interventions to promote physical activity were effective at increasing mean total physical activity levels, and that this activity level was maintained over time; although findings were statistically significant, effect sizes were small.

2.2.2 Spatial/Physical Environment Physical Activity Interventions

The most frequently studied intervention focusing on the physical environment is the use of point-of-decision prompts. Point-of-decision prompts are motivational signs placed in or near stairwells or at the base of elevators and escalators to encourage individuals to increase stair use. These signs can have a variety of messages, but the most common are those that inform people about the health or weight loss benefits of taking the stairs, and those that remind people already predisposed to becoming more active about an opportunity at hand to do so.

Point-of-decision prompts have been shown to be effective in a range of settings, including shopping malls, train, subway, and bus stations, airports, banks, office buildings, and university libraries, and in a variety of population subgroups, including men and women, younger, older, obese and non-obese people, and among various racial/ethnic subgroups. In a review of eleven studies, the Task Force on Community Preventive Services found strong evidence that that point-of-decision prompts were effective at increasing the percentage of people who chose to use the stairs instead of an elevator or escalator, with a median increase in stair use of 2.4%, or a relative increase of 50% (Force on Community Preventive Services, 2010).

Other spatial interventions range from stairwell enhancements (e.g. paint, carpet, playing music in the stairwell, including artwork or other visually stimulating elements) to the creation of or enhancement of access to places for physical activity, e.g. the office gym.

Moore et al (2006) reported several measures used to characterize stairwells, including visibility from main entrance, signage, presence of physical door, and interior lighting and space. These measures (simplified as location, lighting, and access) may influence stair use.

Nicoll (2007) identified several spatial characteristics associated with stair use, including: travel distances from stair to nearest entrance and the elevator, effective area or occupant load of each stair, accessibility of each stair, area of stair isovist (a graphic representation of the horizontal extent of a person's visual field from a specific point of reference within a building floor plan), number of turns required for travel from the stair to closest entrance, and the most integrated path (MIP). Three variables (effective area, area of stair isovist, and number of turns for travel from the MIP), explained 53% of stair use in the 10 buildings studied. Stair width and stair type were the only local-level variables that indicated a significant relationship with stair use (Nicoll, 2007).

In summary, the types of successful spatial environment physical activity interventions that have been reported in the literature include "point-of-decision" prompts to encourage stair use, stairwell enhancements, and the creation of or enhancement of access to places for physical activity. Non-spatial interventions include informational interventions (email prompts, community-wide campaigns), behavioral and social interventions (school-based physical education, social support in community settings, and individually-adapted health behavior change), self-monitoring/motivational interventions (pedometers, diaries), and policy interventions (employee gym memberships) (Kahn et al, 2002).

The diverse methodologies that have been used to measure these outcomes – ranging from self-report to the use of objective devices like accelerometers and people-counters – leave much to be verified in the literature. Where effects were found, there is a great variety in the size of the effects, as well as in the observed statistical power of these effects.

2.2.3 Physical Activity Interventions and Productivity

In a review of the literature, Marshall (2004) reported some evidence that workplace physical activity programs reduced absenteeism, however there was inconclusive evidence in relation to job satisfaction, job stress, and employee turnover; no evidence was found for a positive effect on productivity. This lack of relationship between workplace physical activity programs and worker productivity highlights an important gap in the literature.

2.3 Sedentary Behavior

2.3.1 Sedentary Behavior and Building Spatial Characteristics

There are few studies available that have examined the effects of building design and building element design (ex. layout) on sedentary behavior. Rhodes, Mark, and Temmel (2012) found that, in contrast to other correlates of sedentary behavior (ex. sociodemographic variables, behavioral variables), limited research has been conducted on the cognitive, social, or physical environmental correlates, even though these may be better suited for intervention.

> *"It is proposed that the form of buildings and sites affect physical activity at several spatial scales: …building design such as the programming, layout, and form of the building; and building element design such as the design and layout of elements such as stairs or exercise rooms" (Zimring et al, 2005).*

The design of the vertical and horizontal circulation paths are the main design and facilities management planning decisions that will impact the amount of energy expended by employees in the course of the day (Finch, 2007).

Some of the measures that have been identified as possible correlates of sedentary behavior/physical activity include: location of office building destinations like meeting rooms, kitchen, toilet, and office area (Smith et al, 2013); the location and availability of services (e.g. Coffee kiosks) outside the immediate work environment (Zimring et al, 2005); building circulation (corridors, elevators, stairs, lobbies) (Zimring et al, 2005); naturally lit stairwells and stairwell visibility (Ruff et al, 2013); barriers such as locked doors, grade changes, and non-ergonomic design (Zimring et al, 2005); view of people and activities from exercise areas, central location of activity areas, and wide, unobstructed corridors (Ruff et al, 2013).

Only a few of these variables have been empirically tested, however, and even fewer have been tested on the population of interest (working adults). Much of the literature on sedentary behavior has focused on the elderly and children – which may or may not be applicable to the working adult population. While the literature has identified these as *possible* correlates of sedentary behavior – these have not been verified.

Owen et al (2011) suggests that sitting at work and sitting in the domestic environment may be related to arrangements of furniture, communication technology, and proximal–social factors – although these factors have likewise not been empirically studied.

In conclusion, the types of spatial variables that have been studied in the literature include locational and distance measures (distance from workplace to various building destinations), layout patterns (circulation, vertical transportation, furniture arrangement), spatial quality measures (views/visibility, ergonomics, natural lighting) and accessibility measures (locked doors, signage, number of turns). Although some promising studies have been able to identify the effect these variables have on sedentary behavior, much of the literature was speculative in nature and in need of verification.

2.3.2 Sedentary Behavior Interventions

While the issue of physical activity has received a good amount of attention in the scientific literature, significantly less research has been conducted on sedentary behavior, determinants of sedentary behavior, and the possibility/effectiveness of interventions to reduce sedentary behavior.

In the first randomized control trial to investigate the effects of an intervention specifically targeted to reduce adverse sedentary behavior in the workplace, Evans et al (2012) found that education plus point-of-choice prompts on work computers, used to remind individuals to take a 1-minute break from sitting every 30 minutes significantly reduced the number of, and time spent in, prolonged (>30 minutes) uninterrupted sitting periods compared to education alone, although no difference in total time spent sitting was observed.

In contrast to these findings – in a study on overweight, non-exercising office workers – Kozey-Keadle et al (2012) found that it was possible to reduce total sedentary time through an intervention; breaks from sedentary time, however, significantly decreased in the same period – complicating these findings. The intervention employed in the Kozey-Keadle et al study involved the provision of information about the health risks associated with sedentary time and the benefits associated with increasing light-intensity activity; a list of strategies to reduce sedentary time; a daily checklist to monitor sedentary time; individual counseling on specific ways to overcome participant-specific barriers that inhibit reductions in sedentary time; and participants were given a pedometer to wear during the intervention period, with the stated goal of attaining 7500 steps/day (a goal less than the standard recommendation of 10,000 steps/day, considering the overweight population). At baseline, participants took 6417 steps per day (on weekdays 6121 steps/day), and during the intervention the number of steps per day increased to 8167 (on weekdays 8133 steps/day).

Although Owen et al (2011) reviewed six *workplace* interventions that were unsuccessful at decreasing sitting time (individually tailored physical activity advice or counseling, counseling plus fitness-testing, weekly healthy eating and active living email messages, and the promotion of walking with pedometers, motivational emails, and walking routes), two studies (Walking for Wellbeing in the West & 10,000 Steps Ghent) targeting increases in *daily* walking using pedometers as motivational tools reported a reduction in sitting time, as well as an increase in walking, during the intervention period (Owen et al, 2011). This provides mixed evidence that pedometers can be effective motivational tools to reduce sedentary time.

A study by Swarts et al (2014) found that the addition of prompts to disrupt sedentary behavior is effective at altering aspects of sitting time in the workplace.

Thus, the interventions that have been shown to be successful at decreasing total sedentary time and/or reducing the number of prolonged uninterrupted sitting periods include informational interventions (point-of-choice prompts on work computers, list of strategies to reduce sedentary time) and self-monitoring/motivational interventions (pedometer, daily checklist). These strategies have shown mixed results, however, and warrant verification.

Spatial sedentary behavior interventions have received scant attention in the literature, and this is complicated by the fact that, “At present, no definitive recommendations for how long people should sit or how frequently people should interrupt their sitting time exist – more experimental evidence and intervention studies are needed to shape their development" (Dunstan, Thorp, & Healy, 2011).

2.4 Theoretical Framework

This study works within the framework of the social ecological model – which emphasizes the dynamic interrelations between environmental and personal factors. There has been an increase in the application of ecological models in recent years, and in particular to health problems.

The social ecological models theory posits that environments (of various scales) influence behavior by either prohibiting or affording certain activities or actions, and that intrapersonal variables, interpersonal and cultural factors interact with these environmental influences in the ways that they impact human behavior (Sallis, Bauman, & Pratt, 1998). "Ecological models are believed to provide comprehensive frameworks for understanding the multiple and interacting determinants of health behaviors" (Glanz, 2008).

Four core principles of ecological models of health were proposed by Glanz (2008) :

> *1. There are multiple influences on specific health behaviors, including factors at the intrapersonal (biological, psychological), interpersonal (social, cultural), organizational, community, physical environmental, and public policy levels.*
>
> *2. Influences on behaviors interact across these different levels.*
>
> *3. Ecological models should be behavior-specific, identifying the most relevant potential influences at each level.*
>
> *4. Multi-level interventions should be most effective in changing behavior.*

Social ecological models can be used to understand how various factors simultaneously influence behavior in order to identify elements at each level of influence that might be best targeted for comprehensive interventions (Glanz, 2008).

Applying the theoretical social ecological model framework to buildings, Zimring et al (2005) describes how environment and behavior are inextricably linked, yet are dynamic and ever changing:

> *"The causal relationships between building design and human behavior are very complex. Buildings and sites are deliberately designed to support a set of activities and to create or reinforce a set of cultural assumptions. So, at the outset of any design, it can be said that behavior causes environment. However, as individuals and groups use buildings on a daily basis, they are affected by the built-in physical aspects of the building and site, such as the availability of space for different functions, relationships among spaces, aesthetics, and symbolism. Each of these relationships are potentially mediated and moderated by individual and group knowledge and attitudes. Nonetheless, in the short term, environment influences behavior." (Zimring et al, 2005)*

This framework, applied to sedentary behavior, was chosen because it suggests that a complex interplay between personal circumstances, policies, environmental and social factors determine sedentary behavior, and that no single factor can explain why some people or groups have higher levels of sedentary behavior than other people or groups. This research will focus primarily on the influence of spatial characteristics on sedentary behavior, and in particular the building design and building element design features. This model is graphically represented below, adopted from Zimring et al, 2005.

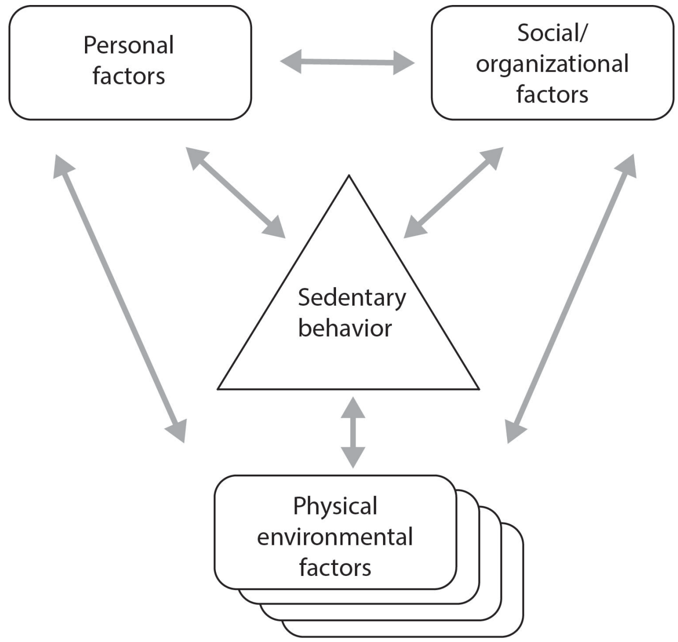

Figure 1*: A social ecologic model of influences on sedentary behavior*

CHAPTER 3: INSTRUMENTS AND MEASUREMENT ISSUES RELATED TO SEDENTARY BEHAVIOR

3.1 Objective Measurement Tools

3.1.1 Accelerometry

Accelerometers differ from pedometers in several critical respects. Pedometers are low-cost devices that measure the number of steps taken, while accelerometers measure acceleration, or the intensity/degree of force exerted. Accelerometers and measure the amount of time spent at different activity intensities, while pedometers merely count the number of times that a threshold is exceeded. Most pedometers use a small swinging mechanical arm, which swings to detect each step; when a movement of the same force as a typical step occurs, the pedometer counts one step. Accelerometers, on the other hand, record the intensity, frequency, and duration of physical activity. The output of a pedometer is number of steps over a given period, while an accelerometer determines 'activity counts,' or a measure of the intensity of physical activity, which can be converted into physical activity levels using validated cut-points.

The ActiGraph GT3x device measures activity using counts-per-minute; different studies have used different counts-per-minute thresholds to distinguish sedentary from non-sedentary activities, with the most commonly used thresholds being 100 and 150 counts-per-minute. According to a study by Kozey-Keadle et al. (2011) the AG 150-counts-per-minute threshold has been shown to have the lowest bias (1.8%) of the AG cut points

3.1.2 Space Syntax

> *"Space syntax is a theory- and computer-based methodology that links quantitative descriptions of form of cities and complex buildings with culture, behavior, and cognition" (Zimring et al, 2005).*

Space syntax attempts to use quantitative analysis to describe the configuration and *spatial relationships* in the built environment – ranging in scales from rooms to buildings to entire city networks – by reducing spatial relationship to a network of lines. This quantitative analysis can then be used to attempt to describe spaces "in such a way that their underlying social logic can be enunciated" (Bafna, 2003), and can be used to predict movement patterns (UCL Depthmap, n.d.).

> *"Space syntax research has found that spatial configuration alone explains a substantial proportion of the variance between aggregate human movement rates in different locations in both urban and building interior space" (Penn, 2003).*

Some measures of office space that have been investigated in relation to sedentary behavior reflect the space syntax methodology, and these include connectivity and integration (Rashid, Craig, & Zimring, 2006).

3.2 Survey Tools

Various survey tools are available to measure self-reported sitting time; these tools vary in their validity and reliability. The International Physical Activity Questionnaire (IPAQ) and the Work Limitations Questionnaire were utilized in the current study.

3.2.1 International Physical Activity Questionnaire

The International Physical Activity Questionnaire (IPAQ) was developed to measure health-related physical activity (PA) in populations. The questionnaire also includes questions about time spent sitting as an indicator of sedentary behavior.

3.2.2 Alternative Sedentary Behavior Questionnaires

Wijndaele et al (2014) reported on the reliability and validity of a self-report, last 7-day sedentary behavior questionnaire (SIT-Q-7d) as compared to accelerometer-derived sedentary time, *and found that this tool was both reliable and valid, although it generally overestimated sedentary time.* "Test–retest reliability (intraclass correlation coefficient (95% CI)) was fair to good for total sedentary time (DQ: 0.68 (0.50–0.81); EQ: 0.53 (0.44–0.62)) and poor to excellent for domain-specific sedentary time" *although* the occupation scale received DQ: 0.66 (0.46–0.79), suggesting fair to good test-retest reliability for the occupational sitting scale. For criterion validity (Spearman rho), significant correlations were found for total sedentary time (DQ: 0.52; EQ: 0.22; all P G0.001).

Clark et al (2011) found that a self-reported measure of workplace sitting time, obtained using the question "Please estimate the total time during the last week that you spent sitting down as part of your job while at work or working from home," was significantly correlated with accelerometer-derived sedentary time (Pearson r = 0.39, 95% confidence interval = 0.22–0.53). Self-reported breaks per sitting hour, based on the question "How many breaks from sitting (such as standing up or stretching or taking a short walk) during one hour of sitting would you typically take at work?" with a choice of responses (0, 1, 2, 3, 4, and 5 or more) were also statistically significantly correlated with accelerometer-derived breaks (Spearman rho = 0.26, 95% confidence interval = 0.11–0.44). The authors suggest that this workplace sitting measure has acceptable properties for use in observational studies of sedentary behavior.

Chau et al (2011) found that the Workforce Sitting Questionnaire (WSQ), an adapted measure of total and domain-specific sitting time based on work and non-workdays, has acceptable properties for assessing sitting time, and would be suitable for use in research investigating the relationships between sitting time and health. The WSQ had fair to excellent test-retest reliability and acceptable criterion validity against accelerometer-derived sedentary time. However sitting time at work on a workday showed a low correlation for all participants with accelerometer sedentary time at work. The WSQ showed fair to excellent test–retest reliability by domain in women with ICCs ranging from 0.59 to 0.95 and poor to excellent test–retest reliability by domain in men with ICCs ranging from 0.23 to 0.86.

These studies suggest that there is a variety of self-report measures to assess time spent sedentary, and in some cases breaks in sedentary time, which have acceptable validity and reliability for use in sedentary research. These self-report measures have been shown to correlate highly with objectively measured sedentary time.

After review, the IPAQ was chosen for its widespread use and repeated validation.

3.2.3 Work Limitations Questionnaire

The Work Limitations Questionnaire was developed to measure the impact of chronic health conditions on job performance and work productivity. “The WLQ is a reliable and valid self-report instrument for measuring the degree to which chronic health problems interfere with ability to perform job roles. Unlike available questionnaires, it addresses the content of the job through a demand-level methodology" (Lerner et al, 2001). The WLQ has been shown to be reliable and valid in several samples (Allaire, 2003; Lerner et al, 2001; Walker, Michaud, & Wolfe, 2005).

The WLQ contains four subscales addressing different job demands, including time demands, physical demands, mental/interpersonal demands, and output demands.

Brown et al (2013) used the Work Limitations Questionnaire (WLQ) to assess employee presenteeism, and found significant associations between employee presenteeism and sedentary time before and after work (positive) and light-intensity PA (total, and during workday lunch hours) (negative)

In the current study the Work Limitations Questionnaire was chosen to measure at-work productivity loss.

3.2.4 Workplace Environmental Satisfaction Survey

The Workplace Environmental Satisfaction Survey was developed to gauge occupants' level of satisfaction with the indoor environment. The survey has several sections, which ask occupants to report their level of satisfaction with various aspects of the indoor spatial environment, including various measures related to stairwells & elevators as well as layout (meeting spaces, restrooms, coffee/break rooms, etc.). Other sections include questions about job satisfaction, mood, and demographics.

In a study by Hua and Yang (2012) workspace distance from service and amenity areas (conference rooms, reception desks, copy areas, kitchens, and elevators) was inversely associated with step counts and job satisfaction. The authors suggest that neighborhood layouts tend to better support walking behavior and job satisfaction.

CHAPTER 4: RESEARCH STATEMENT AND HYPOTHESES

4.1 Research Statement

Recently, increased attention has been paid to the deleterious effects of sedentary behavior on physiological outcomes. This is due largely in part to the growing body of literature demonstrating the negative physiological outcomes associated with sedentary behavior, ranging from weight gain to increased mortality risk.

Sedentary behavior is context-specific, with individuals engaging in different types of sedentary behaviors in the different domains of their life (transportation, leisure time, workplace, etc.). In order to address the issue of sedentary behavior comprehensively we must understand how it operates in each of these domains in order to generate context-specific solutions/interventions. Considering individuals spend a large portion of their waking lives in the workplace, the workplace is a critical domain for sedentary behavior research. Understanding the determinants of sedentary behavior in the workplace could prove valuable in developing interventions to reduce sedentary time. In order to develop interventions, however, the modifiable correlates of sedentary behavior must first be identified.

While there is some previous literature exploring the relationship between sedentary behavior and sociodemographic and behavioral variables, research into the ways spatial characteristics of office spaces influence sedentary behavior are virtually nonexistent, even though these may be more appropriate for targeted intervention efforts.

This research intends to fill the gap in the literature by linking sedentary behavior and spatial characteristics of work environments, in an attempt to identify the spatial characteristics that might be targeted for a sedentary behavior intervention. This research is novel in that it 1) evaluates a number of different correlates of workplace design and sedentary behavior to see which, if any, are associated with one another, and 2) uses accelerometer-derived sedentary time measures, which have been infrequently used in studying the relationship between spatial variables and sedentary time.

4.2 Hypotheses:

This study investigates the relationship between workplace spatial characteristics, objectively measured sedentary behavior patterns of office workers, and employee presenteeism. The hypotheses tested are:

- H.1. Office workers have less sedentary behaviors when their workstations are located relatively closer to shared service and amenity spaces than those whose workstations are located further away from those spaces.
- H.2. Office workers have more sedentary behaviors when their workstations have low visibility, measured by the space syntax variable "Connectivity," than those whose workstations have high visibility.

H.3. Office workers have more sedentary behaviors when their workstations have low overall integration compared to those whose workstations have high overall connectivity.

H.4. Employee presenteeism (level of impairment as measured by the WLQ) will be positively associated with occupational sedentary behavior.

CHAPTER 5: METHODS

5.1 Study Sites

Data was collected from two sites owned by Cornell University in Ithaca, NY.

The buildings of study were chosen according to the following inclusion criteria: 1) buildings where a large majority of the individuals are employed in desk-based occupations/perform desk-based tasks, and 2) buildings that serve administrative, rather than academic, functions. Criterion 2) was included due to the nature of the work being studied. Sites were sought that most closely reflect the office culture/layout/nature of the work of large corporations, such that the findings could be more readily generalized to this population.

Up-to-date building floor plans in CAD were acquired through the Facilities Management department of the University. The locations of the cubicle partitions were added to the CAD floor plan during the study. Private offices, shared offices, open-plan workstations (cubicles), and reception workstations were all included in this study.

Site 1

Site 1 is a building located on the central campus of the university and serves administrative functions. The building is composed of five masses of varying heights arranged around a central square court. The masses are shifted off one another, which along with the centralized court, allows for natural light in almost every space. The building has a gross area of 87,977 sq. ft. and a net area 74,912 sq. ft.

Site 2

Site 2 is located adjacent to the central campus of Cornell University in the East Hill Plaza Shopping Center, which provides retail services to students, staff and neighbors and provides office space to university departments. The office space located within the shopping center houses administrative functions, and these were the focus of this study. The 10-acre, 110,000 sq. ft. neighborhood shopping center was acquired and redeveloped by Cornell University in 1984 to halt its deterioration, protect nearby Cornell lands, and for long-term expansion needs. The university departments housed in this building include Human Resources, Payroll, Sponsored Program Services, Financial Aid & Admissions, and Publications & Media among others; the complex also houses a variety of retail providers and a grocery store.

5.2 Participants

Participants were full-time office workers in the subject buildings, who spent most of their work hours in the office setting. A variety of jobs were represented in this sample (for example administrative assistants and specialized staff members in a variety of departments) however all were administrative in nature.

5.2.1 Recruitment

Individuals in the subject buildings were individually sent one (1) email inviting them to participate in the study. Individuals who chose to participate replied to this email and signed up for a 15-minute meeting where the lead researcher visited the participant's workstation and performed the study. In a few cases, while the researcher was conducting the study with an individual recruited through the traditional email method, an individual from a neighboring cubicle overheard the study and decided to participate on the spot.

Participants were asked if they would like to receive a copy of their own physical activity data (collected by the ActiGraph (GT3X+) accelerometer). This summary of individual activity patterns was sent to participants approximately two weeks after the data collection period. This feedback allowed participants to visualize and reflect on their own personal activity patterns.

5.2.2 Compensation:

Participants were put into a drawing/lottery to receive one of five $100 gift certificates to a local grocery store.

5.3 Instruments

This research used multiple instruments. Each will be described in detail, below.

4.3.1 Survey

A paper-based survey (Appendix A) was used which included questions adopted from the International Physical Activity Questionnaire, the Work Limitations Questionnaire (omitted from Appendix A, proprietary survey), and modified questions of a workplace collaboration environment questionnaire.

5.3.1.1 International Physical Activity Questionnaire

The International Physical Activity Questionnaire (IPAQ) is a measure of self-reported time spent sitting and breaks in sitting. Rosenberg et al (2008) report that both the short and long versions of the IPAQ sitting questionnaire have sufficient reliability for use in sedentary research. Good test-retest reliability and acceptable validity were observed. More information about the IPAQ can be found in Appendix B.

5.3.1.2 Work Limitations Questionnaire

The Work Limitations Questionnaire (WLQ) is a measure of Employee Presenteeism, developed by Lerner and colleagues in collaboration with Tufts Medical Center. Employee Presenteeism is the extent to which health conditions adversely affect at-work productivity. The questions of the WLQ are answered using a five-point Likert scale. The questions of the WLQ are used to calculate the WLQ Index, or the percent of lost productivity.

> "The WLQ Index is derived by summing all items and transforming the total mathematically to a 0 (limited none of the time) to 100% (limited all of the time) continuum, representing the reported proportion of time spent impaired." (Brown et al, 2013)

In this study the WLQ was used to evaluate presenteeism, and to evaluate the extent to which employee presenteeism is associated with sedentary behavior. Lerner et al. (2001) found that the WLQ demonstrated high reliability and validity. More information about the WLQ can be found in Appendix B.

5.3.1.3 Workplace Environmental Satisfaction Survey

Modified questions of the Workplace Environmental Satisfaction Survey were used, adapted from Hua & Yang (2014). The Workplace Environmental Satisfaction Survey was developed by

Hua and Yang at Cornell University, and is based on the International Physical Activity Questionnaire (IPAQ), a previous workplace survey developed by Hua (the Workplace Collaboration Environment Questionnaire) (Hua et al., 2010; Hua et al., 2011) and literature. The majority of questions are structured as a 5-point Likert scale.

5.3.2 Objective Measurement Tools

5.3.2.1 Accelerometer-derived Sedentary Time

An objective measure of physical activity level and sedentary time was collected using the ActiGraph GT3X accelerometer, as it has been demonstrated to have acceptable validity and reliability in our population (Healy et al., 2011). Another factor contributing to the choice of the ActiGraph GT3X is due to its widespread use in previous studies; of the studies that used an accelerometer measure, most used the ActiGraph accelerometer. More information about the ActiGraph GT3X and accelerometry in general can be found in Appendix B.

5.3.2.2 Proximity to Amenity Spaces

An objective measure of the proximity between each participant's workstation and a variety of shared spaces (meeting room, coffee/break area, printer/copy area, reception, and restroom). The proximity from workstation to different shared spaces was measured by the orthogonal walking distances along the corridors from the center of a cubicle or an office to the center of the shared spaces, proceeding along the center of any hallways or work areas. All measurements were performed on the up-to-date floor plans in CAD format; the software utilized was Autodesk AutoCAD 2014 Educational version.

5.3.2.3 Space Syntax

The Space Syntax measure of connectivity measures the number of immediate neighbors that are directly visually connected to a space (a static local measure). Integration measures how "deep" a space is relative to all other spaces (a static global measure), or in other words, how many turns one would have to make to reach all other spaces in the network from that space, using shortest paths. Workspaces can be ranked from the most integrated to the most segregated (Klarqvist, 1993). More information about the use of Space Syntax in previous studies can be found in Appendix B.

In this study the Space Syntax measures of Connectivity and Integration were used. This analysis was performed using Space Syntax software (depthmapX-0.30) and up-to-date building floor plans.

Depthmap: Space Syntax Software

UCL Depthmap is an Open Source application that "performs a set of spatial network analyses designed to understand social processes within the built environment" (*UCL Depthmap, n.d.)* In different contexts, spatial modeling using depthmapX can help forming assumptions about social behavior in space and model spatial and social relationships. It takes input in the form of a plan of the system, and is able to construct a map of visually connected locations within it, as well as give measures of how integrated spaces are.

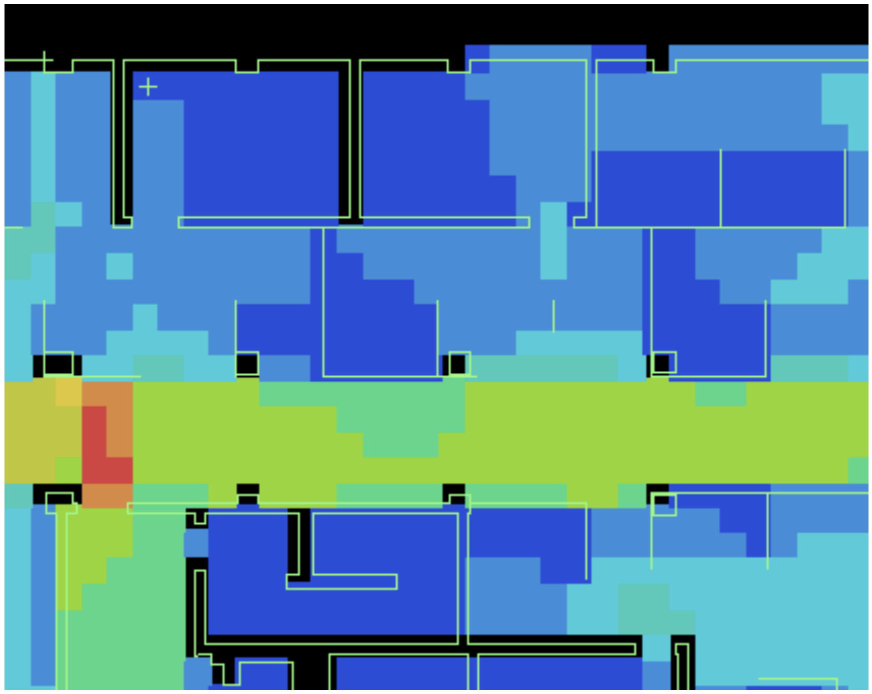

Figure 2: *Connectivity Heat Map*

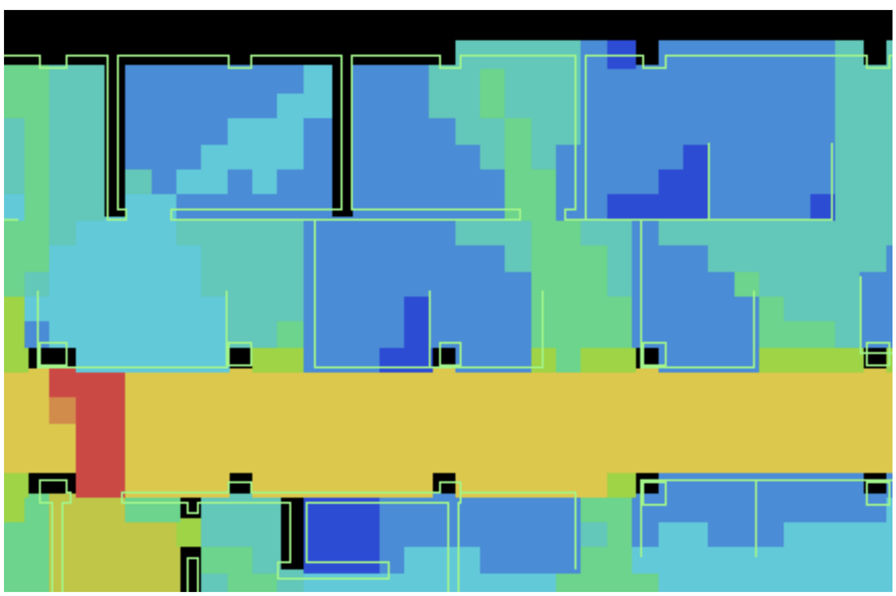

Figure 3: *Integration Heat Map*

Space Syntax Considerations

Considering connectivity is a measure of visual access, connectivity measurements were made at eye-level (approx. 1.6m). Using this methodology, cubicle partitions and walls that were lower than 1.6m were not included on the floor plan for connectivity analysis, as visibility was not restricted by their presence.

For measures of integration all partitions and walls were included, regardless of height.

5.4 Data Collection

Data collection occurred between Feb. 12th and March 13th, 2015. Once all steps of the study were explained to each participant and they were provided an opportunity to ask questions, they signed an informed consent form if they wished to enroll in the study. All procedures were reviewed and approved by the Cornell Institutional Review Board, IRB file # 1410005068.

Building occupants who agreed to participate received a paper-based survey and an ActiGraph (GT3X+) accelerometer to wear for five consecutive weekdays. Each participant was provided with an ActiGraph GT3X+ accelerometer (and elastic belt), which was initialized to sample acceleration at a rate of 30 Hz.

Participants were instructed to wear the device only while they were in the building of study, and to wear the device positioned on the right hip. Participants were asked to put the meter on first thing in the morning as soon as they arrived at work, and to keep the activity meter on all day while at work. Participants were asked to remove the device if they left the building for any reason during the workday (e.g. to attend a meeting in a different building, to go out to lunch) and to put on the device as soon as they returned to the building. These instructions were given both verbally during a one-on-one demonstration by the researcher, and were printed on an instructions sheet that was left with the participant for later reference.

Because participants left their accelerometers on their desks when leaving the building, the trips to/from the entrance to their workstations were not recorded by the accelerometer. For example, if, upon arrival to the building, an individual climbed three flights of steps to reach their workstation, this activity would not be recorded by the accelerometer, as the individual would not have reached their workstation to put on the accelerometer. Likewise, individuals were asked to leave their accelerometers behind when exiting the building, and so any activity performed after removing the accelerometer while exiting the building was not recorded.

Participants were also provided with a daily wear-time log, in which they were asked to record the times they put on and took off the activity-tracking device each day. This allowed the researcher to verify the times when the device was being worn. If individuals forgot to remove the accelerometer before leaving the building they were asked to note this on their time log. These pieces of data were removed during data analysis.

Accelerometers, logbooks, and surveys were collected from the participants at the end of the 5-day period.

5.5 Data Analysis

Data from paper surveys were coded and input into an Excel spreadsheet.

5.5.1 ActiGraph Data Cleaning

Data from the ActiGraph GT3X accelerometers were downloaded using ActiLife software (Version 6, Full Edition). The accelerometers were programmed to continuously collect data at 10-second intervals, and data was aggregated into 1-minute epochs for analysis. As individuals were instructed to only wear the device while in the building, non-wear time was removed from the data sets. Non-wear time was defined as any period of >60 minutes where counts/minute were consecutively zero, with a spike tolerance of two minutes. Non-wear time was further compared to user wear logs, with additional non-wear periods being removed manually.

Data were included if accelerometer wear time was at least 5 hours per day on at least four workdays. Individuals who met these criteria had their entire data set included in the analysis (even if on one day the individual only wore the device for three hours, as long as on the four other days the participant wore the device for at least 5 hours all five days were included).

All data were analyzed using Vector Magnitude. Vector Magnitude refers to the magnitude of the resulting vector that forms when combining the sampled acceleration from all three axes on the device.

When looking at epoch level data, the Vector Magnitude (or VM) can be defined as:

$$Vector\ Magnitude = VM = \sqrt{(Axis\ 1)^2 + (Axis\ 2)^2 + (Axis\ 3)^2}$$

Previous studies have used different AG thresholds to determine sedentary time, with the most frequently used thresholds being 100-counts-per-minute and 150-counts-per-minute. A study by Kozey-Keadle et al (2012) found that the AG 150-counts-per-minute threshold has the lowest bias (1.8%) of the AG cut points, and so the 150-counts-per-minute threshold was used in this study (Kozey-Keadle et al, 2011). For this reason, the 150-counts-per-minute threshold was utilized as the cut-point for sedentary behavior.

The Freedson Adult Vector Magnitude (VM3, 2011) cut-points for different physical activity levels were used. The cut-points are as follows: 0-149 counts/minute, Sedentary; 150-2689 counts/minute, Light; 2690-6166 counts/minute, Moderate; 6167-9642 counts/minute, Vigorous; and >9643, Very Vigorous.

This text will refer to 'bouts' of sedentary behavior. A bout of sedentary behavior is defined as a continuous period of at least one minute where ActiGraph accelerometer counts per minute were below 150. The length of a sedentary bout is determined by the length of time between ActiGraph measurements of >150 counts/minute.

CHAPTER 6: RESULTS

Because not all participants wore the Actigraph accelerometer (i.e. some participants only completed the survey), results will be presented in two ways. Section 6.1 will provide the results from the entire sample, including individuals who only completed the survey. Section 6.2 will provide the results from the subset of the sample that wore the Actigraph accelerometer.

6.1 FULL SAMPLE DESCRIPTIVE STATISTICS

Demographics are reported in two different ways. The first includes all individuals who participated in the study, whether they wore the ActiGraph accelerometer or not. The second includes only those individuals who wore the ActiGraph accelerometer.

6.1.1 Demographics

A total of 57participants participated in this study. Females represented a significant majority of participants (79%, n=45). This was likely due to self-selection bias, considering not all occupants of the subject buildings were included in the study; only those who chose to participate after receiving an invitation email participated. Alternatively, this could be a reflection of the gender composition of these workplaces.

Participants’ ages were fairly evenly distributed, with 4% (n=2) aged between 25 and 29, 11% (n=6) between 30 and 34, 12% (n=7) between 35 and 39, 9% (n=5) between 40 and 44 , 16%

(n=9) between 45 and 49, 18% (n=10) between 50 and 54, 14% (n=8) between 55 and 59, 12% (n=7) between 60 and 64, and 5% (n=3) over 65 years old (Figure 5.1).

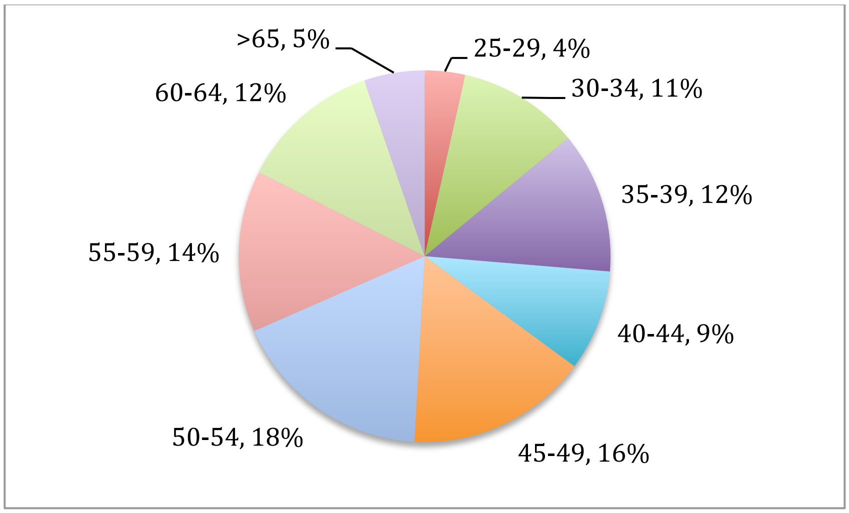

Figure 4: *Age*

Table 1
Age and Gender

	n	%
Gender		
Male	12	21%
Female	45	79%
Age		
18-24	0	0%
25-29	2	4%
30-34	6	11%
35-39	7	12%
40-44	5	9%
45-49	9	16%
50-54	10	18%
55-59	8	14%
60-64	7	12%
>65	3	5%

More than half of the participants (55%, n=31) weighed less than 160 pounds. Five percent of the individuals (n=3) weighed less than 120 pounds, and fifty percent of the participants (n=28) weighed between 120 and 160 pounds. Four percent (n=2) weighed more than 240 pounds.

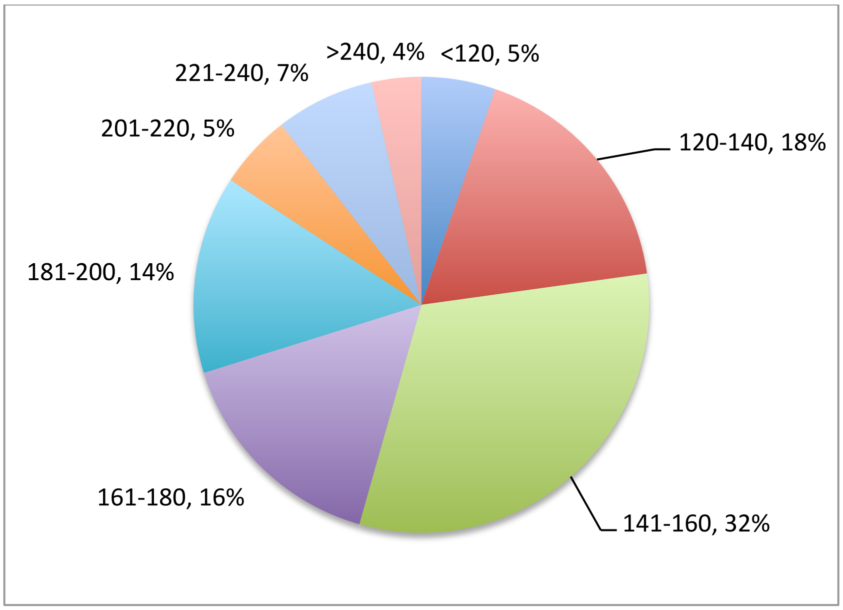

Figure 5: *Weight*

The average body mass index score (BMI) was 26.87 (SD=5.04), which indicates that the average lies in the 'overweight' category. The minimum, median, and maximum BMI were 21, 25, and 42, respectively. Using the guidelines of BMI<25 as healthy weight, 25<BMI<30 as overweight, 30<BMI<39 as obese, and >39 as extremely obese, 43% (n=23) of the participants were of healthy weight, 31% (n=17) were overweight, 20% (n=11) were obese, and 6% (n=3) were extremely obese.

This sample had a slightly lower average BMI than the average American (BMI=26.6 for men and 26.5 for women). Fewer individuals in the sample were obese than the national average, as approximately 34.9% of Americans are obese (CDC). Slightly fewer individuals were obese in this sample than the New York state average of 25.4%.

Table 2
Weight and BMI

	n	%
Weight		
<120	3	5%
120-140	10	18%
141-160	18	32%
161-180	9	16%
181-200	8	14%
201-220	3	5%
221-240	4	7%
>240	2	4%
BMI		
Healthy <25		43%
Overweight 25-29		31%
Obese 30-39		20%
Extremely obese 40+		6%

The majority (86%, n=49) of participants were of white/Caucasian race, with 7% (n=4) Asian, and 2% (n=1) were Black/African American, Hispanic, and 'Other' respectively.

Over two-thirds (68%, n=39) of the participants reported that their job roles were "Administration/Support". The remaining participants indicated that they were Management (14%, n=8), Research Staff (9%, n=5), Technician (4%, n=2), and Faculty (4%, n=2).

Sixty-six percent of the participants (n=38) had received a bachelors degree or higher, with 33% (n=19) receiving a Bachelor's degree and 33% (n=19) receiving Postgraduate degrees. Twelve percent (n=7) received an Associates degree, and 16% (n=9) attended some college. Five percent (n=3) indicated that they graduated from high school and that this was the highest level of education they had received.

Table 3
Race, Education, and Position

	n	%
Race		
White	49	86%
Black/African American	1	2%
Asian	4	7%
Native Hawaiian/ Pacific Islander	0	0%
Hispanic	1	2%
American Indian/ Alaska Native	0	0%
Other	1	2%
Education		
Some high school or less	0	0%
Associate degree	7	12%
High school graduate	3	5%
Bachelor's degree	19	33%
Attended some college	9	16%
Postgraduate	19	33%
Position		
Faculty	2	4%
Undergraduate Student	0	0%
Technician	2	4%
Post Doc	0	0%
Research Staff	5	9%
Management	8	14%
Graduate Staff	0	0%
Administration/ Support	39	68%

More than four out of five participants (83%, n=47) indicated that they were in overall good or very good health (53% 'Good', 30% 'Very Good'). Fourteen percent (n=8) indicated that they were in overall fair health, and 4% (n=2) indicated they were in poor health. Three quarters (75%, n=43) of the participants reported that they got less exercise than they needed, and one quarter (25%, n=14) believed they got as much exercise as they needed.

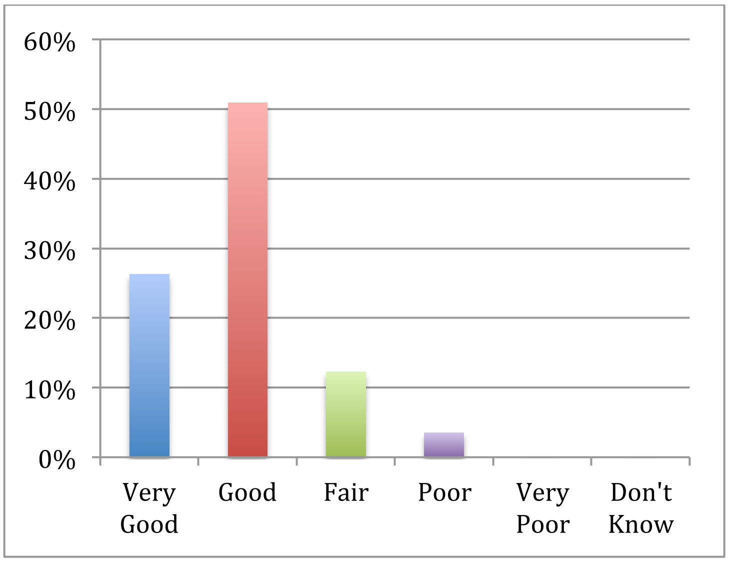

Figure 6: *Overall Health*

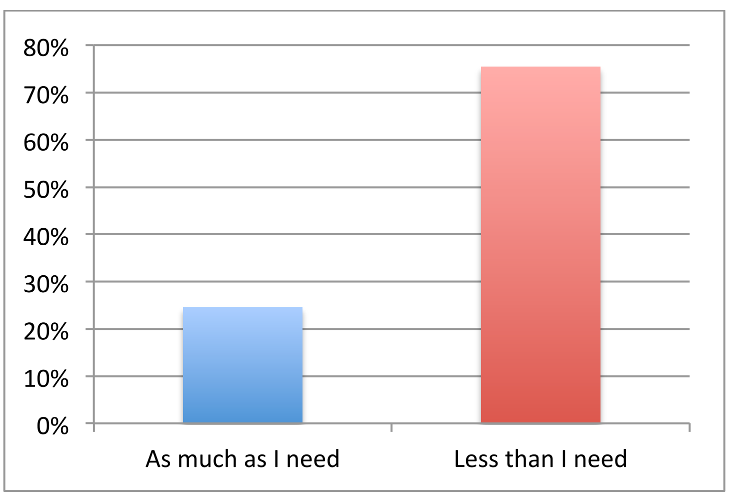

Figure 7: *Amount of Exercise*

Table 4
Self-Reported Health and Exercise

	%	n
Overall Health		
Very Good	26%	15
Good	51%	29
Fair	12%	7
Poor	4%	2
Very Poor	0%	0
Don't Know	0%	0
Amount of Exercise		
As much as I need	25%	14
Less than I need	75%	43

The average number of hours worked per day was 8.29 (SD=1.17), and the average number of hours worked per week was 41.92 (SD=6.83). The median number of hours worked per day was 8 and the number of hours per week 40. Of the hours worked per week, participants reported that they spent an average of 39.59 hours in the buildings of study (SD=5.66).

Figure 8: *Average Hours Worked per Day*

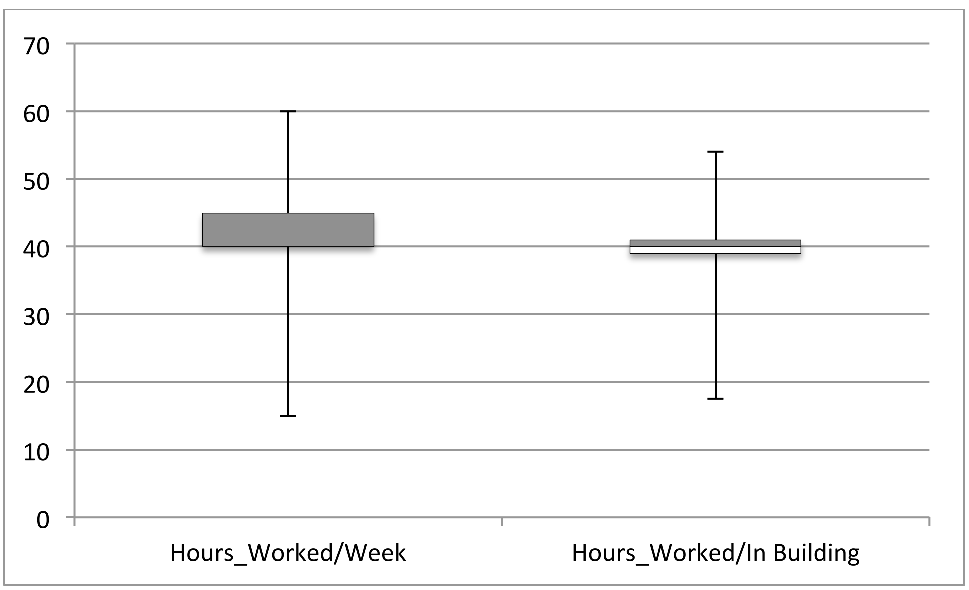

Figure 9: *Average Hours Worked per Week*

Over three quarters (78%) of the participants had worked in the building for over two years, and 68% had worked in their particular office/workstation for over two years. The minimum time that an individual had worked in a workspace in the building was 1.5 months, the maximum time that an individual had worked in the building was 31 years 5 months, and the maximum time that an individual had worked in their particular workstation was 28 years 11 months. The average length of time that the participants had worked in the building was 8 years 9 months (SD=8.35yr), and the average length of time that the participants had worked in their particular workstations was 5 years 5 months (SD=6.17yr). The median length of time that the participants had worked in the building was 6 years, and the median length of time that the participants had worked in their particular workstations was 4 years.

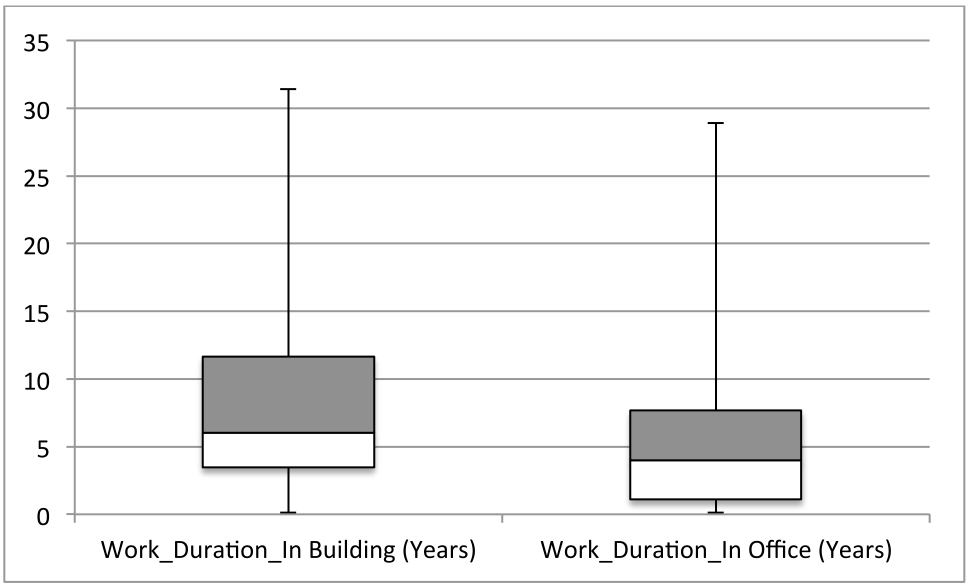

Figure 10: *Years Worked in Building and in Present Workspace*

6.1.2 Physical Activity

In the following section different levels of physical activity will be defined as follows:

Moderate Physical Activity – physical activities that make you breathe somewhat harder than normal and may include activities like carrying light loads, jogging, bicycling, swimming, dancing, etc.

Vigorous Physical Activity – physical activities that make you breathe much harder than normal. These may include things like heavy lifting, digging, heavy construction work, or climbing up the stairs.

6.1.2.1 Physical Activity at Work

Nineteen percent of participants indicated that they engaged in 10 continuous minutes of vigorous physical activity *as a part of their work* on at least 1 day of the week, while 58% indicated that they did not perform 10 continuous minutes of vigorous PA on any days as part of their work. Of the 11 individuals who performed 10 continuous minutes of vigorous PA on at least one day, eight also reported the average amount of time that they spent per day performing vigorous physical activity as part of their work; the average was 23.5 minutes (SD=22.61) with a maximum of 60 minutes.

Seven percent of participants indicated that they engage in 10 minutes of continuous moderate PA *as a part of their work* on at least 1 day per week, and 70% indicated that they did not perform 10 minutes of continuous moderate PA on any days as part of their work. Of the four individuals who reported the average amount of time that they spent per day performing moderate physical activity as part of their work, the average was 31 minutes (SD=50.04) with a maximum of 120 minutes.

Thirty two percent of participants indicated that they engaged in 10 minutes of continuous walking *as a part of their work* on at least 1 day of the week, while 53% indicated that they did not perform 10 minutes of continuous walking on any days as part of their work. Of the 22 individuals who reported the average amount of time that they spent per day walking as part of their work the average was 31.7 minutes (SD=25.72) with a maximum of 120 minutes.

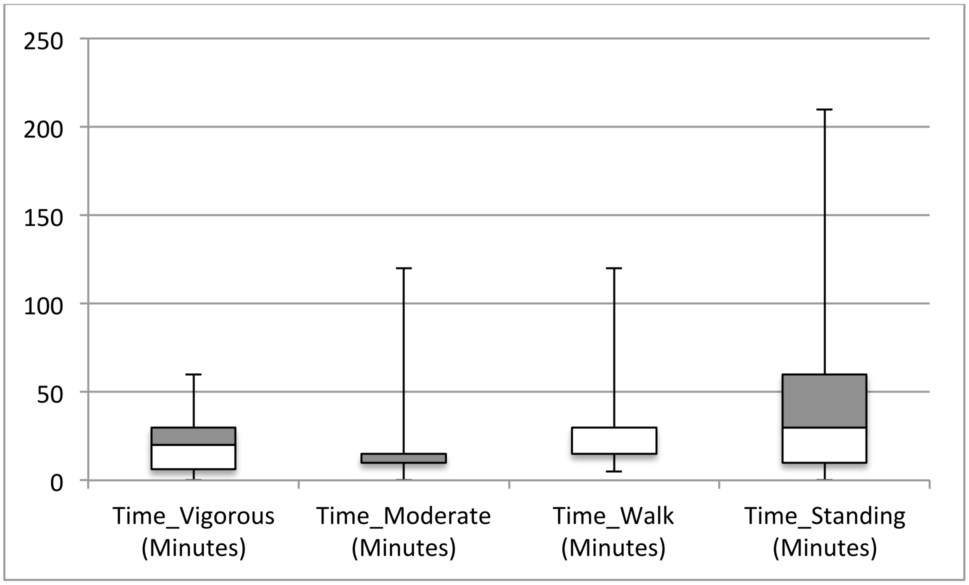

Figure 11: *Self-Reported Average Minutes per Day Engaged in Various Activities at Work*

Individuals reported sitting for an average of 7.17 hours per day (SD=1.2) and standing for an average of 38 minutes (.633 hours) per day (SD=42.78 minutes). Fourteen percent (n=8) of the participants reported that they did not stand as a part of their work.

Figure 12: *Self-Reported Average Hours per Day Sitting at Work*

Table 5
Self-reported Activity at Work

	Min/Max	Average (SD)	Median
Vigorous activity at work			
No. of days per week	0/7	0.77 (1.70)	0
Ave. no. min/day	0/60	23.50 (22.61)	20
Moderate activity at work			
No. of days per week	0/7	0.41 (1.40)	0
Ave. no. min/day	0/120	31.00 (50.05)	10
Walking at work			
No. of days per week	0/7	1.52 (2.34)	0
Ave. no. min/day	0/120	31.70 (25.72)	30
Standing at work			
Ave. no. min/day	0/210	38.06 (42.78)	30
Sitting at work			
Ave. no. hours/day	3/10	7.18 (1.20)	7.5

6.1.2.2 Total Physical Activity

Participants were asked to indicate the number of days per week that they engaged in at least 30 minutes of moderate physical activity *at any point in the day*. More than half of the participants (61%) indicated that they engaged in 30 minutes of moderate PA on three days per week or less, with 23% engaging on three days per week, 4% engaging on 2 days per week, 11% engaging on only one day per week, and 25% engaging on no days per week (0 days per week). Less than half of the participants (39%) indicated that they engaged in 30 minutes of moderate PA on at least four days per week, with 32% engaging in 30 minutes of moderate PA on at least five days per week and 9% engaging on all seven days of the week. The average number of days/week that participants engaged in 30 minutes of moderate PA was 3 (SD=2.38). The median was also 3 days per week.

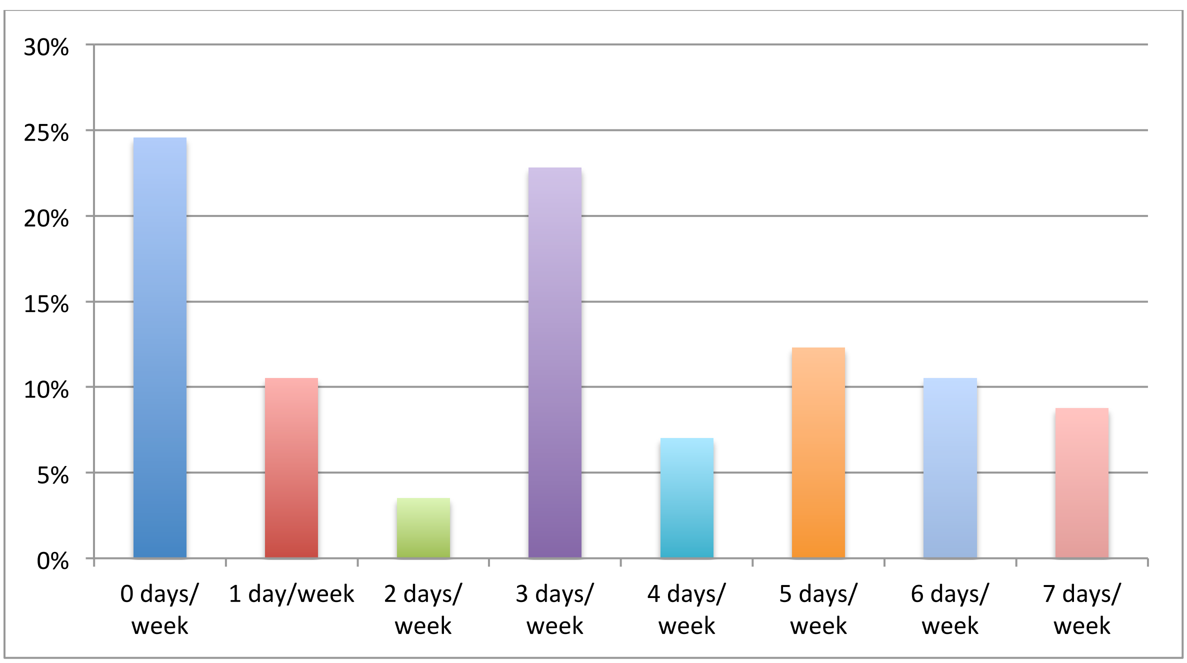

Figure 13: *Average Number of Days per Week Engaged in 30 Minutes of Moderate Physical Activity at Any Point in the Day*

Participants were also asked to indicate the number of days per week that they engaged in at least 10 minutes of walking *at any point in the day*. Nearly half of the participants (44%) indicated that they engaged in 10 minutes of walking on three days per week or less, with 16% engaging on three days per week, 5% engaging on 2 days per week, 11% engaging on only one day per week, and 12% engaging on no days per week (0 days per week). Approximately half of the participants (51%) indicated that they engaged in 10 minutes of walking on at least four days per week, with 46% engaging in 10 minutes of walking on at lest 5 days per week. The average number of days/week that participants engaged in 10 minutes of walking was 3.75 (standard deviation=2.36). The median was 4 days per week.

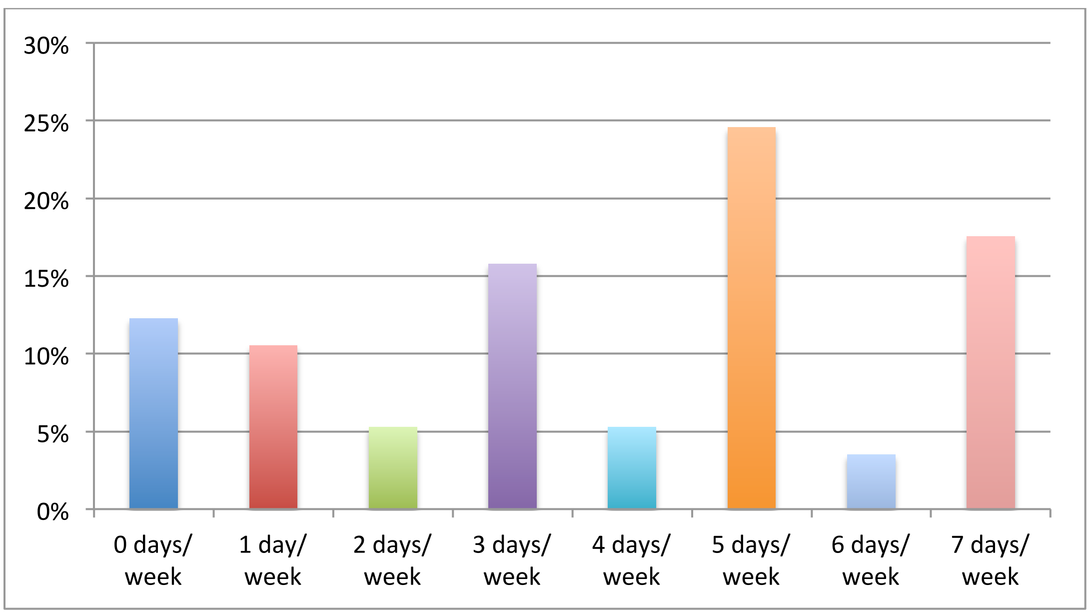

Figure 14: *Average Number of Days per Week Engaged in 10 Minutes of Walking at Any Point in the Day*

Table 6
Average No. of Days/Week Engaged in Moderate PA or Walking at Any Point in the Day

	%	N
No. days/week engaged in 30 minutes of moderate PA		
0 days/week	23%	13
1 day/week	11%	6
2 days/week	4%	2
3 days/week	23%	13
4 days/week	7%	4
5 days/week	12%	7
6 days/week	11%	6
7 days/week	9%	5
No. days/week engaged in 10 minutes of walking		
0 days/week	11%	6
1 day/week	11%	6
2 days/week	5%	3
3 days/week	16%	9
4 days/week	5%	3
5 days/week	23%	13
6 days/week	4%	2
7 days/week	18%	10

6.1.3 Satisfaction

Individuals were asked to rate their job satisfaction, their satisfaction with the spatial environment of the workplace, and whether the spatial environment supports their ability to perform work based on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree.

No individuals were strongly dissatisfied with their job, and only 5% (n=3) were dissatisfied. Eleven percent of respondents (n=6) reported they were neutral about their job satisfaction.

Eighty three percent (n=46) of respondents were either satisfied or very satisfied with their jobs, with 45% (n=25) being satisfied and 38% (n=21) being very satisfied. The average job satisfaction rating was 4.16, or slightly above satisfied.

Nineteen percent of respondents were dissatisfied to some extent with the spatial environment of their workplace; Four percent of respondents (n=2) reported they were very unsatisfied with the spatial environment and 15% (n=8) reported they were unsatisfied. Eighteen percent of respondents (n=10) reported they felt neutral about the spatial environment. Sixty-three percent (n=35) of respondents reported being satisfied to some extent with the spatial environment, with 38% (n=21) reporting they were satisfied and 25% (n=14) reporting they were very satisfied. The average spatial environment satisfaction rating was 3.67, in between neutral and satisfied.

No individuals reported that the spatial environment strongly interfered with their ability to perform work, however 5% (n=3) of respondents felt that the spatial environment interfered with their ability to perform work. Twenty-eight percent of respondents (n=10) felt neutral about the effect of the spatial environment on their performance. Seventy-seven percent of respondents felt that the spatial environment supported their ability to do work to some extent, with 27% (n=15) reporting that they felt the spatial environment strongly supported their ability to perform work. The average rating for support from the spatial environment was 3.98, or just below the level of satisfied.

Table 7
Job and Spatial Satisfaction

	%
Job Satisfaction	
Very Dissatisfied	0%
Dissatisfied	5%
Neutral	11%
Satisfied	45%
Very Satisfied	38%
Satisfaction with the spatial environment	
Very Dissatisfied	4%
Dissatisfied	15%
Neutral	18%
Satisfied	38%
Very Satisfied	25%
Spatial environment supports ability to perform work	
Strongly Disagree	0%
Disagree	5%
Neutral	18%
Agree	50%
Strongly Agree	27%

Individuals were asked to indicate how frequently they experienced a variety of feelings while at work based on a 5-point Likert scale where 1=Always 2=Daily 3=Several times/week 4=Seldom and 5=Never.

Seventy-one percent (n=39) of respondents reported feeling fatigued either seldom or never. Twenty percent (n=11) felt fatigued several times per week, and only 7% (n=4) reporting that they felt fatigue daily. Sixty-five percent (n=36) reported feeling sleepiness seldom or never; 25% (n=15) reported feeling sleepiness several times per week, and only 11% (n=6) reported feeling sleepy on a daily basis.

Four percent (n=2) reported feeling stressed 'always,' and 18% (n=10) reported feeling stressed on a daily basis. Forty percent (n=23) reported feeling stressed several times per week. Thirty-seven percent (n=21) of respondents reported feeling stressed seldom or never.

A majority (61%, n=35) of respondents reported feeling irritable seldom or never. Twenty-eight percent (n=16) reported feeling irritable several times per week, seven percent (n=4) reported feeling irritable daily, and four percent (n=2) reported feeling irritable 'always.'

Only seven percent (n=4) of respondents reported getting headaches 'always' or daily, and 14% (n=8) reported getting headaches several times per week. Seventy-seven percent (n=44) reported getting headaches either seldom or never.

A majority of the respondents (68%, n=39) reported feeling in a good mood at least daily. Twenty-eight percent (n=16) reported feeling in a good mood several times per week, and only 2% (n=1) reported that they were seldom in a good mood.

Table 8
Frequency of Experiencing Various Feelings at Work

	Always	Daily	Several Times/Week	Seldom	Never
Feeling					
Unusual Fatigue	0%	7%	20%	56%	15%
Sleepiness	0%	11%	25%	63%	2%
Stress	4%	18%	40%	35%	2%
Irritability	4%	7%	28%	54%	7%
Headaches	2%	5%	14%	54%	23%
Good mood	7%	61%	28%	2%	0%

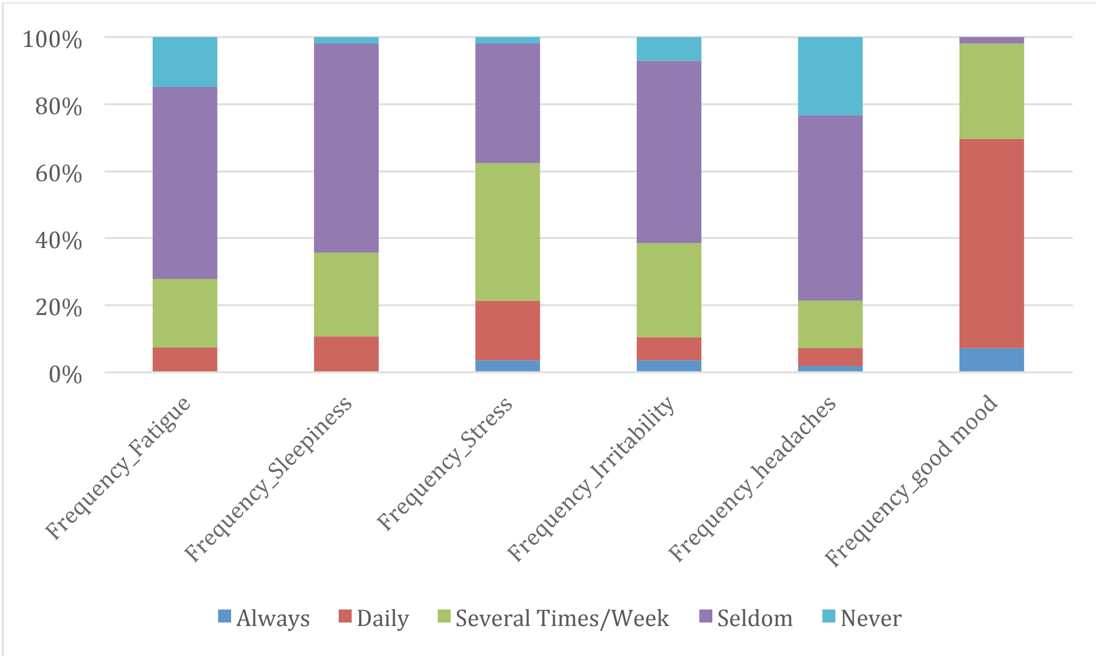

Figure 15: *Frequency of Experiencing Various Feelings at Work*

6.1.4 Staircases and Elevators

Only one of the study sites, building 1, was a multi-level building. For this reason, the following questions regarding staircases and elevators in the building were not evaluated for the participants of building 2.

Individuals were asked to indicate the number of times that they walk the stairs during a typical workday as well as the total number of stories walked. On average, individuals reported walking the stairs 4.21 times per day (SD=3.63), with a minimum of zero times, a maximum of 20 times, and a median of 3.5 times per day. On average individuals walked a total of 4.18 flights of stairs per day (SD=6.67), with a minimum of zero, a maximum of 40 flights, and a median of 2 flights per day.

Over three quarters of the respondents (76%, n=32) reported that their preferred method of vertical transportation was the stairs, and the remaining 24% (n=10) noted that it depends on the number of flights of stairs. Of those ten individuals who reported that their use of the stairs depended on the number of flights to ascend or descend, 10% (n=1) reported that they would use the stairs if it was only one flight, 10% (n=1) if two flights, 60% (n=6) if three flights, and 20% (n=2) if four flights. For those individuals who reported that their use of the stairs depended on the number of flights, the average number of flights was 2.2 (SD=.82), with a median of 2 flights, a minimum of one flight and a maximum of four flights.

Individuals were asked to report the factors that influenced their stair use. The most frequently reported influence was exercise (31%, n=13). Number of floors to travel (26%, n=11), direction of travel (17%, n=7), and a preference for stairs (12%, n=5) were the next most frequently reported influences. Additionally, time-related pressure from work (7%, n=3), time spent waiting for elevator (5%, n=2), and speed of elevator (2%, n=1) were mentioned, although infrequently.

Fifty-seven percent (n=24) chose "Other" and wrote in their responses. Of these, 54% (31% of total, n=13) reported that "Exercise" was an important influence, and another 21% (12% of total, n=5) reported that they "Prefer stairs."

Other factors that were written in by participants include: "elevators are "clunky" here", "fitness", "elevator unreliable", "healthier and faster", "fear of elevators", "need to stretch legs", "good idea to take stairs", and "better for me."

Individuals were asked to report the factors that influenced their elevator use. The most frequently reported influence was carrying heavy things, which was reported by 56% of participants (n=23). Other frequently mentioned influences on elevator use include Injury or health problems (20%, n=8), to avoid getting sweaty or out of breathe (7%, n=3), Convenient (2%, n=1), and Laziness (2%, n=1).

Twelve percent (n=5) chose “Other” and wrote in their responses. These included: “elevator is old/decrepit”, “don't use elevator”, “rarely, if ever, use elevator”, “shortage of time”, and “not knowing where stairs are.”

Individuals were asked to report the factors that encouraged them to walk the stairs. The most frequently reported factor that encouraged walking the stairs was exercise, reported by 36% of the sample (n=15). Other frequently mentioned factors include Staircase close to building entrance (24%, n=10), Motivated by friends/colleagues who I walk with (21%, n=9), The look and feel of the stairs (10%, n=4), and Staircase lit by natural daylight (10%, n=4).

Sixty-two percent (n=26) chose “Other” and wrote in their responses. Of these, 58% (36% of total, n=15) indicated that Exercise was a main factor motivating stair use. Other factors that were written in by participants include:

“stretch and move after sitting for a bit,” “fitness,” “don't take elevator,” “faster than elevator,” “elevator unreliable,” “number of floors,” “self motivation,” “trying to be healthy,” “healthy,” “better for me,” "its really the only exercise or mildly strenuous activity I do all day," and “prefer stairs”

Table 9
Influences on Stair and Elevator Use

	N	%
First choice for vertical travel		
Elevator	0	0%
Stairs	32	76%
Depends on the number of floors	10	24%
1	1	10%
2	1	10%
3	6	60%
4	2	20%
Main influence on stair use		
Direction of Travel	7	17%
Time-related pressure from work	3	7%
Crowdedness of Elevator	0	0%
Number of floors to travel	11	26%
Time spent waiting for elevator	2	5%
Speed of elevator	1	2%
Other, please specify	24	57%
Main influence on elevator use		
Convenient	1	2%
Carrying heavy things	23	56%
The perception of not being fit enough to climb stairs	0	0%
The perception that stairs are too far to reach the destination	0	0%
To avoid getting sweaty or out of breath	3	7%
Laziness	1	2%
Injury or health problems	8	20%
Other, please specify	5	12%
Factors encouraging you to walk stairs		
The look and feel of the stairs	4	10%
Staircase lit by natural daylight	4	10%
Motivated by friends/colleagues who I walk with	9	21%
Staircase close to building entrance	10	24%
Motivating signage	0	0%
Other, please specify	26	62%

Satisfaction with various aspects of elevator and stairwell design and maintenance are included below. These questions were answered on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree. Both descriptive statistics (min, average, standard deviation, median, and max) as well as percentage counts are provided for each variable.

Participants reported that the staircases are easily accessible from their offices (average 4.49, 83% agree or strongly agree) however fewer reported that the staircase is visible from the entrance of the building (average 4.02, 73% agree or strongly agree).

Only 32% agreed or strongly agreed that staircases looked pleasant, and 22% disagreed. Twenty-nine percent of participants reported that they often talk to colleagues when they walk the stairs, while 44% reported they do not. Seventy-eight percent of respondents reported they agreed or strongly agreed that the staircase was located along their primary path of travel Eighty-six percent reported that the stairwells are visible from the elevator waiting area.

Table 10
Elevator and Stairwell Measures

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The staircase entrance(s) are visible from where I enter the building.	0%	22%	5%	22%	51%
The elevator(s) are visible from where I enter the building.	10%	27%	10%	22%	32%
The staircase(s) are easily accessible from my office/cubicle.	0%	2%	5%	34%	59%
The elevator(s) are easily accessible from my office/cubicle.	2%	2%	10%	32%	51%
The elevator waiting time is long.	12%	24%	29%	17%	17%
The staircase(s) are safe to walk.	0%	0%	5%	34%	61%
The staircase(s) look pleasant.	0%	22%	46%	20%	12%

I talk to colleagues often when I walk stairs.	10%	34%	27%	27%	2%
The staircase is located along the primary path of my travel.	0%	5%	17%	46%	32%
The staircase entrance(s) are visible from elevator waiting area.	0%	5%	7%	46%	41%
The stair entry door(s) exist.	0%	0%	2%	44%	54%
The staircase is well maintained.	0%	2%	5%	56%	37%
The stair entry door(s) are often held open.	32%	32%	10%	17%	10%
I am comfortable with the height of step.	0%	0%	5%	49%	46%
I am comfortable with the temperature in staircase(s).	0%	0%	2%	61%	37%
There is natural daylight in staircase.	44%	24%	7%	17%	7%
Daylight in the staircase encourages me to use stairs.	20%	10%	45%	20%	5%
The staircase is wide enough for short conversations to take place.	2%	20%	24%	49%	5%
The staircase is clean.	0%	5%	3%	70%	23%
I have short conversations with my colleagues when I walk stairs.	5%	29%	32%	29%	5%

6.1.5 Layout impact

Individuals were asked to rate the extent to which they agreed or disagreed with several statements relating to interactive behavior in the workspace, because this is a possible reason that office workers get out of their chairs. Responses were given on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree.

The majority of individuals (79%, n=46) felt that there was enough space in their office/cubicle to hold a face-to-face meeting; only 12% (n=7) disagreed or strongly disagreed that there was enough space to hold a face-to-face meeting in their office/cubicle. The average rating was 3.84, just below the level of ‘agree’, and there was a median rating of 4, ‘agree.’

The majority of respondents (69%, n=40) felt that the furniture (table, chair, outlet, etc.) in their workspace were appropriate for meetings, while 21% (n=12) felt that the furniture was not appropriate. The average rating was 3.57, about half way between ‘neutral’ and ‘agree’, and there was a median rating of 4, ‘agree.’

Sixty-five percent of respondents (n=38) agreed or strongly agreed that there were different sized meeting spaces on the floor where they were working, and 31% (n=18) disagreed or strongly disagreed. The average rating was 3.48, about half way between ‘neutral’ and ‘agree’, and there was a median rating of 4, ‘agree.’

Only one individual (2%) disagreed that the arrangement and furnishings of meeting spaces support meeting effectiveness, while the majority (71%, n=39) agreed or strongly agreed. The average rating was 3.85, and there was a median rating of 4, ‘agree.’

Table 11
Meeting Space Variables

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There is enough space in my office/cubicle to hold a face-to-face meeting.	9%	3%	9%	53%	26%
There is appropriate furniture (e.g., table, guest chair, power outlet, etc.) for meetings in my office/cubicle.	14%	7%	10%	47%	22%
There are different-sized meeting rooms/spaces on the floor where I am working.	10%	21%	3%	41%	24%
The arrangement and furnishing of the meeting rooms/spaces supports meeting effectiveness.	0%	2%	27%	55%	16%

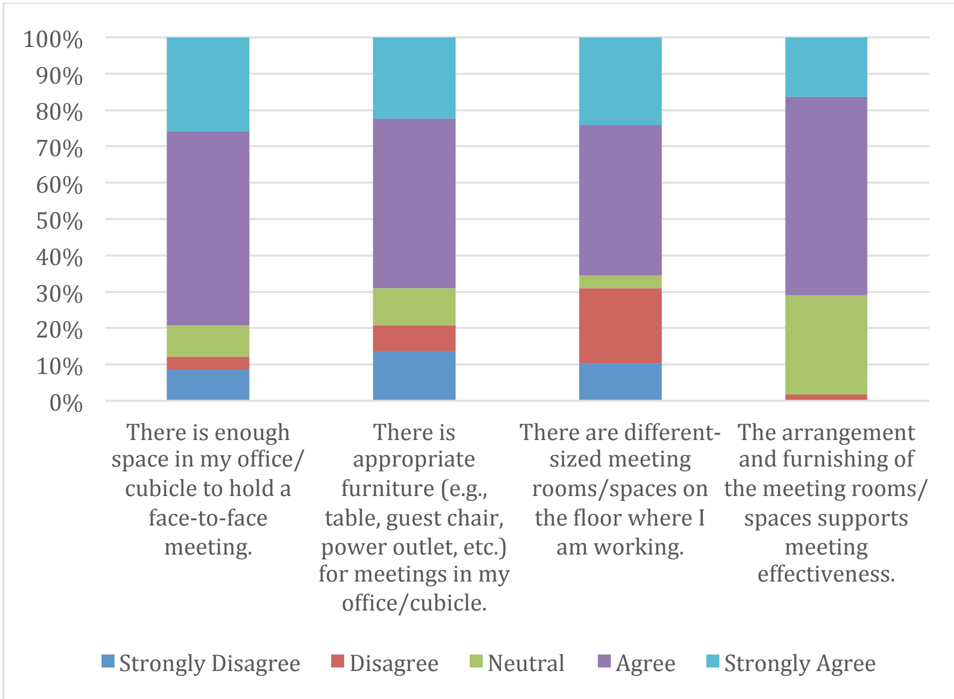

Figure 16: *Meeting Space Variables*

Participants were asked to rank the main factors that influence their choice of meeting space. Five options were provided, as well as an "Other, Please specify" option. Participants ranked their choices using number 1-5, or 1-6 if they chose to fill in the "Other" item. The five options that were provided were: Room capacity, Furniture, Technology, Distance to my office/cubicle, and Room with window(s). Only the 36 individuals who ranked all five (or six) items have been included in this analysis; ten of these individuals filled in the "Other" item.

Overall, Room capacity was the most important factor in choosing a meeting room, being ranked first 72% of the time (n=26), second 19% of the time (n=7) and third 6% of the time (n=2). Technology was the second most important factor, being ranked second 36% of the time (n=13).

The least important factors were Rooms with windows, which was ranked fifth 53% of the time (n=19), and Distance to office, which was ranked fifth 36% of the time (n=13).

Table 12
Factors Influencing Meeting Room Choice

	Ranked First	Ranked Second	Ranked Third	Ranked Fourth	Ranked Fifth	Ranked Sixth
Room Capacity	72%	19%	6%	0%	3%	0%
Furniture	3%	14%	36%	42%	3%	3%
Technology	3%	36%	53%	6%	3%	0%
Distance to office	3%	19%	3%	25%	36%	14%
Room with Windows	0%	6%	3%	28%	53%	11%
Other	19%	3%	0%	3%	3%	0%

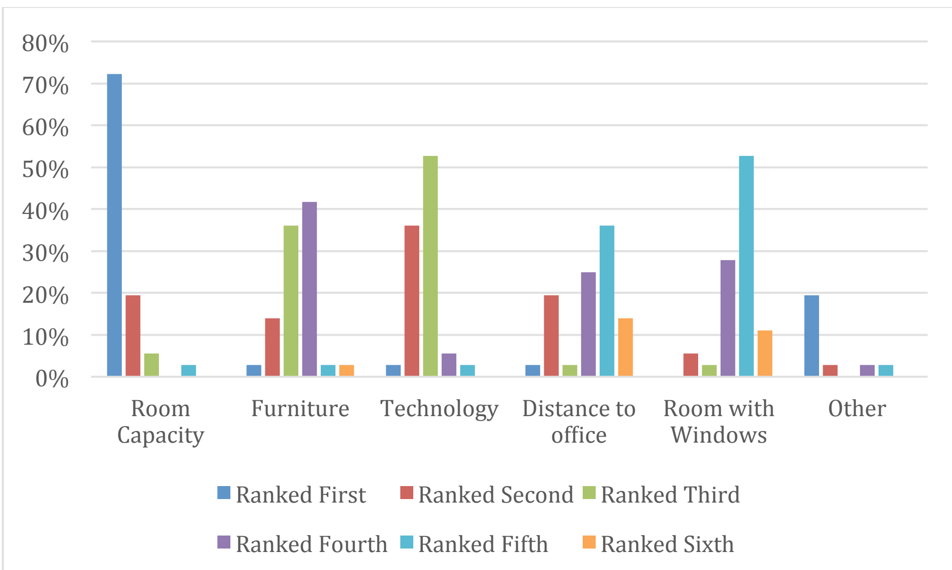

Figure 17: *Factors Influencing Meeting Room Choice*

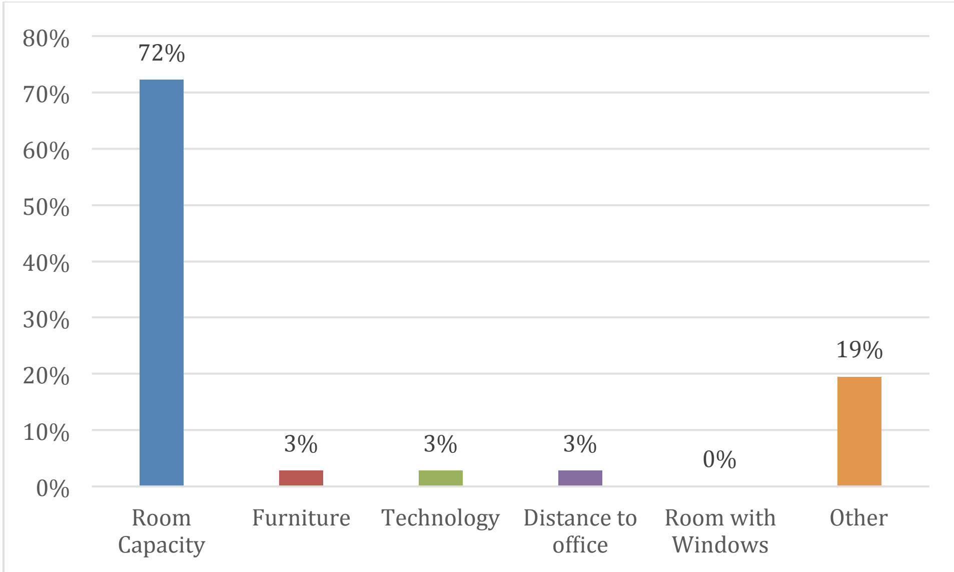

Figure 18: *Percent of Time Factor Ranked as Most Important Influence on Meeting Room Choice*

Of the 10 individuals who filled in the "Other" item, 70% (n=7) ranked their filled in option first. These included "No meeting room on my floor" and "Availability". Two individuals ranked their "Other" item second, one noting "Availability" and the other "Lighting." One individual ranked their "Other" item fifth, and noted "convenience of others attending the meeting"

Individuals were asked how often they take a walk during their lunch or other break time, and were asked to respond on a 5-point Likert scale with scales 1=Never, 2=Seldom, 3=Sometimes, 4=Often, or 5=Always. The majority of people (70%, n=41) walk "Sometimes" or more frequently, and only 27% (n=16) seldom or never walk on their breaks.

Individuals were asked whether they disagreed or agreed with the following two statements, and were asked to respond on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree: "Do you think workplace technology (e.g., email, internet messengers, etc.) increases your sedentary behavior?” and “Do you prefer email or instant message to talking in person with your colleagues?”

The majority of individuals (86%, n= 50) agree or strongly agree that workplace technology increases sedentary behavior, and only 5% (n=3) disagree or strongly disagree. Forty-one percent (n=23) of individuals prefer or strongly prefer email or instant message to talking in person, while 37% (n=21) prefer talking in person.

Table 13
Workplace Habits

	%
Frequency of walking during lunch or other break	
Never	5%
Seldom	22%
Sometimes	43%
Often	22%
Always	5%
Workplace technology increases your sedentary behavior	
Strongly Disagree	2%
Disagree	3%
Neutral	9%
Agree	38%
Strongly Agree	48%
Prefer email or IM to talking in person	
Strongly Disagree	9%
Disagree	28%
Neutral	23%
Agree	37%
Strongly Agree	4%

6.1.6 Distance Measures

6.1.6.1 Self-reported Distance Measures

Individuals were asked to report the number of times they visit various amenity spaces in a typical day, including meeting rooms, printing/copy area, mail room, coffee/break room, restroom. Individuals were asked to estimate the distance between their workspace and these amenity spaces, and whether they had to travel between floors to reach these amenity spaces.

Meeting Spaces: On average, individuals made 1.13 trips (SD=1.34) to meeting spaces on the same floor as their workstation per day, and an average of 0.6 (SD=0.81) trips to meeting spaces on other floors per day. The maximum number of reported trips to meeting spaces on the same floor was 5, and the maximum number of reported trips to meeting spaces on other floors was 3. Fifty-seven percent (n=32) of respondents reported making at least one trip per day to a meeting space on their floor: 29% (n=16) reported making one trip, 18% (n=10) reported making two trips, 5% (n=3) reported making three trips, and 5% (n=3) reported making five trips. Forty-one percent (n=23) reported making no trips to meeting spaces on their floor.

Fifty percent (n=21) of respondents indicated that they made at least one trip per day to a meeting space on another floor: 31% (n=13) reported making one, 17% (n=7) reported making two trips, and 2% (n=1) reported making three trips. Fifty percent of respondents (n=21) reported making no trips to meeting spaces on other floors.

Individuals were asked to estimate the distance from their workspace to the meeting space they use most frequently on their floor, and also the distance to meeting space they use located on other floors of the building. Thirty-four participants indicated the distance to meeting spaces on their floor, with the average distance of 39.7 feet (SD=32.80). The minimum reported distance to a meeting space was 5 feet, the median distance 30 feet, and the maximum distance 150 feet.

Twenty-eight individuals reported that they visited meeting spaces on other floors of the building, with nearly half (46%, n=13) having to travel only one floor. Twenty-one percent (n=6) travel two floors, 7% (n=2) travel three floors, 21% (n=6) travel four floors, and one individual (4%) travels five floors to reach a meeting space on another floor. The average reported distance to a meeting space on another floor of the building was 110.65 feet (SD=116.34), with a minimum, median, and maximum distance of 18, 50, and 500 feet, respectively.

Printing: Individuals indicated that they made trips to the printer/copy area an average of 5.37 times per day (SD=4.51), with a minimum of zero times (14%, n=8), median of five (13%, n=7), and maximum of twenty times per day. Forty-one percent (n=23) indicated they made trips to the printer more than five times per day. Most participants (93%, n=37) did not have to travel between floors to reach the printer/copy area (number of floors = 0). Five percent (n=2) traveled one floor to reach the printer/copy area, and 3% (n=1) traveled three floors. The average reported distance to a printer/copy area was 110.65 feet (SD=116.34), with a minimum of 18 feet, median of 50 feet, and maximum of 500 feet.

Mail Room: Individuals indicated that they made trips to the mail room an average of 0.63 times per day (SD=0.93), with a minimum and median both zero (57%, n=32), and maximum of five times per day. Forty-one percent (n=23) indicated they made trips to the mail room either once or twice per day. Most participants (57%, n=21) did not have to travel between floors to reach the mail room (number of floors = 0). Forty-four percent (n=16) of participants had to travel at least one floor to reach the mail room, with 22% (n=8) traveling one floor to reach the mail room, 3% (n=1) traveling two floors, 11% (n=4) traveling three floors, and 8% (n=3) traveling four floors. The average reported distance to a mail room was 53.69 feet (SD=57.55), with a minimum of 1 foot, median of 35 feet, and maximum of 275 feet.

Coffee/Break Area: Individuals indicated that they made trips to the coffee/break area an average of 2.9 times per day (SD=2.4), with a minimum of zero (14%, n=8), median of two (23%, n=13), and maximum of ten times per day. Forty-seven percent (n=27) indicated they made trips to the coffee/break area three or more times per day. Most participants (78%, n=31) did not have to travel between floors to reach the coffee/break area (number of floors = 0). Twenty-three percent (n=9) of participants had to travel at least one floor to reach the coffee/break area. The average reported distance to a coffee/break area was 48.42 feet (SD=36.51), with a minimum of 4 feet, median of 47.5 feet, and maximum of 200 feet.

Restroom: Individuals indicated that they made trips to the restroom an average of 3.63 times per day (SD=1.34), with a minimum of one, median of 3.5, and maximum of eight times per day. Eighty-one percent (n=47) indicated they made trips to the restroom three or more times per day. Most participants (59%, n=27) did not have to travel between floors to reach the restroom (number of floors = 0), and forty-one percent (n=19) of participants had to travel at least one floor to reach the restroom. Thirty-five percent (n=16) had to travel one floor, and 7% (n=3) had to travel two floors to reach the restroom. The average reported distance to a restroom was 60.2 feet (SD=47.67), with a minimum of 10 feet, median of 50 feet, and maximum of 200 feet.

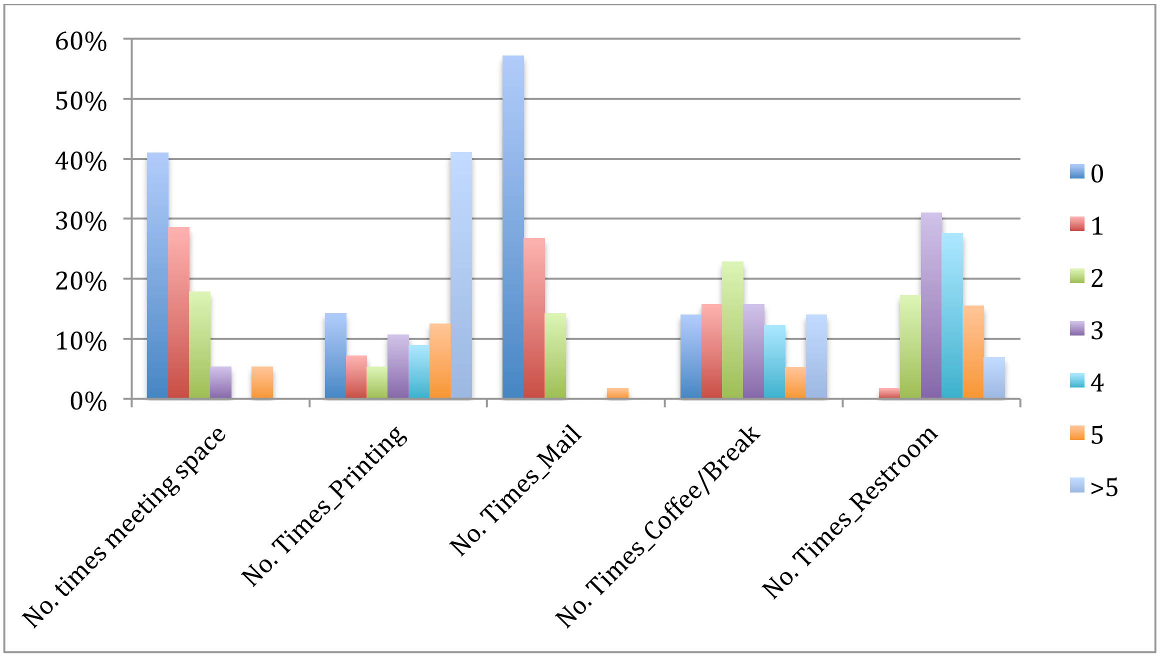

Figure 19: *Average Number of Times per Day Participants Visit Various Amenity Spaces*

Table 14
Average Number of Times per Day Participants Visit Various Amenity Spaces

	0	1	2	3	4	5	>5
Ave. no. of times per day visiting:							
Meeting room	41%	29%	18%	5%	0%	5%	0%
Printer/copier	14%	7%	5%	11%	9%	13%	41%
Mail Room	57%	27%	14%	0%	0%	2%	0%
Coffee/break area	14%	16%	23%	16%	12%	5%	14%
Restroom	0%	2%	17%	31%	28%	16%	7%

Table 15 Self-Reported Distance From Workspace to Various Amenity Spaces			
	Min/Max	Average (SD)	Median
Distance, in feet, from workspace to:			
Meeting room	0/150	39.71 (32.8)	30
Printer/copier	1/100	21.65 (19.12)	100
Mail room	1/275	53.69 (57.55)	35
Coffee/break area	4/200	48.42 (36.51)	47.5
Restroom	10/200	60.20 (47.67)	50

6.1.6.2 Objectively Measured Distance

Objective distance measures were also taken from the center of participants' workspaces to the center of the following amenity spaces: restroom, meeting room, printer/copier, and coffee/break area. On average, individuals were 145.5 feet from restrooms, 97.36 feet from meeting rooms, 46 feet from printer/copier, and 105.42 feet from coffee/bar area.

Table 16 Objectively Measured Distance from Workspaces to Amenity Areas			
	Min/Max	Average (SD)	Median
Distance, in feet, from:			
Restroom (M/F)	65/350	145.50 (70.63)	126
Meeting Room	21/354	97.36 (65.59)	81.5
Printer/Copier	6/179	46.00 (46.73)	29.5
Coffee/Bar area	16/316	105.42 (85.03)	88

6.1.6.3 Comparison of Objectively Measured and Self-Report Distance Measures

Overall, the objective measurements were significantly higher than the self-reported distances, suggesting that participants significantly underestimated physical distances from their office to these shared spaces. Comparisons of average and median distances are provided below.

Table 17
Comparison of Objectively Measures and Self-Report Distances to Amenity Spaces

	Average (Self-Report)	Average (Objective Measure)	Median (Self-report)	Median (Objective Measure)
Distance, in feet, from:				
Restroom (M/F)	60.20	145.50	50	126
Meeting Room	39.71	97.36	30	81.5
Printer/Copier	21.65	46.00	20	29.5
Coffee/Bar area	48.42	105.42	47.5	88

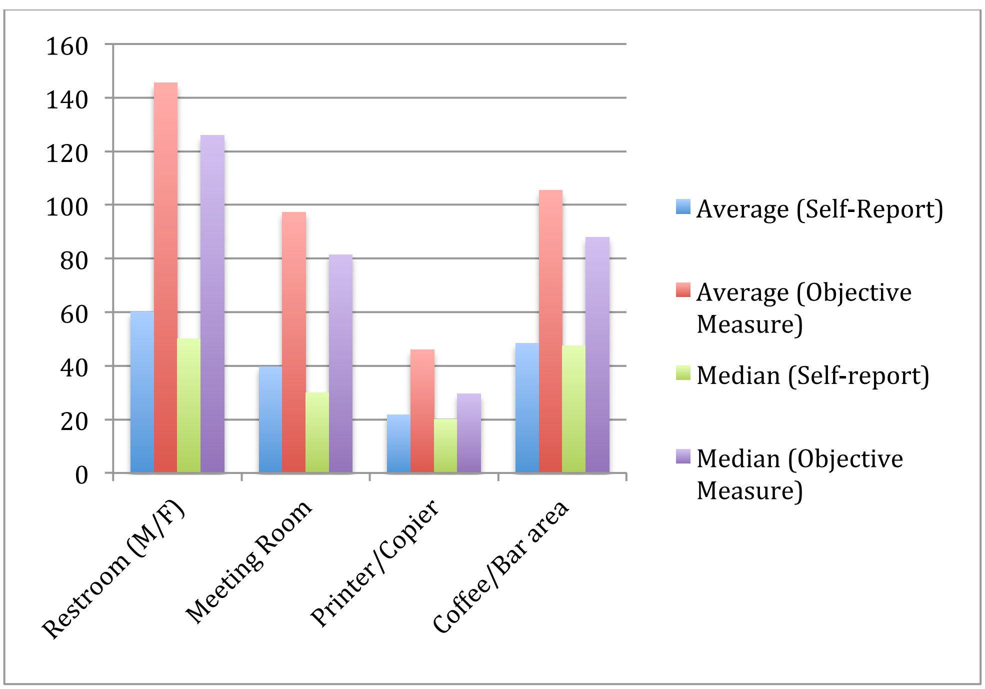

Figure 20: *Comparison of Objectively Measures and Self-Report Distances to Amenity Spaces*

6.1.7 Work Limitations Questionnaire

Individuals who did not answer a sufficient number of questions to calculate the WLQ Productivity Loss Score were removed from analysis, resulting in a total of 55 valid WLQ responses.

Following the methodology set forth by Brown et al. (2013), employees were categorized according to their WLQ Index score, using cutoffs from the WLQ scoring documentation: less than 5% as no impairment, 5% to 10.9% as “mild impairment,” 11% to 16.9% as “moderate impairment,” and 17% to 100% as “severe impairment.”[51] Given the small proportion of participants across moderate and severe conditions (<6%), this variable was dichotomized into “no impairment” (WLQ Index score less than 5%) and “impairment” (WLQ Index score 5% or greater) for analyses. WLQ subscale scores were derived as an average of the responses to relevant items and then dichotomized on the median into “high” or “low,” with “low” used as the referent group for analyses.

The four WLQ subscale scores include the Time Management Scale, Physical Scale, Mental/Interpersonal Scale, and the Output Scale. These values of these scales are used to compute the WLQ Productivity Loss score. The WLQ Productivity Loss score is interpreted as the percentage of productivity loss in the past two weeks due to presenteeism relative to a healthy benchmark sample. The benchmark sample consists of employees who had WLQ scale scores of zero (not limited by health).

The average scores for the subscales were as follows: time management, 10.65%; physical demands 10.91%; mental/interpersonal demands, 12.05%; and output demands, 9.09%.

The average WLQ Productivity Loss score was 3% (SD=4%), with a minimum score of 0% (no impairment), maximum score of 15% (moderate impairment), and median score of 2% (no impairment). Seventy-eight percent (n=43) of participants were categorized as having no impairment, 18% (n=10) were categorized as having mild impairment, and 4% (n=2) were categorized as having moderate impairment.

Figure 21: *WLQ Productivity Loss Score*

Using the dichotomized categories of no impairment and impairment (as WLQ Productivity Loss score of less than 5% and greater than 5%, respectively), 78% (n=43) of respondents were categorized as having no impairment, while 22% (n=12) were categorized as having some impairment.

Table 18 Work Limitations Questionnaire Statistics			
	Min/Max	Average (SD)	Median
WLQ Productivity Loss Score	0%/15%	3% (4%)	2%
Time Management Subscale	0/75	10.65 (17.75)	0
Physical Subscale	0/75	10.91 (16.5)	0
Mental Interpersonal Subscale	0/50	12.05 (13.17)	12.5
Output Subscale	0/75	9.09 (16.57)	0

6.1.8 Connectivity

Connectivity, a measure of local visibility, varied significantly between spaces. The minimum rating for connectivity was 36.08, and the maximum was 205.83. An example of a workspace that is rated high on connectivity, and one rated low on connectivity, are provided in FIGURE 22, below. These are relative measures, based on the floorplan that was analyzed. The average connectivity rating was 86.58 (SD=42.91), and a median of 80.45.

Different floors, as well as different office types, had different levels of connectivity (discussed in section 6.3 ANOVA).

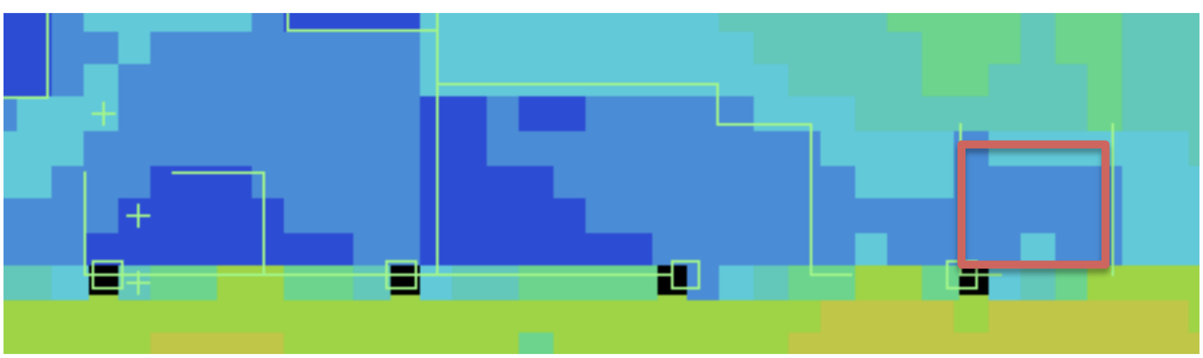

Figure 22: *Connectivity Heat Map, Identified Workspace has High Connectivity* (rating 152)

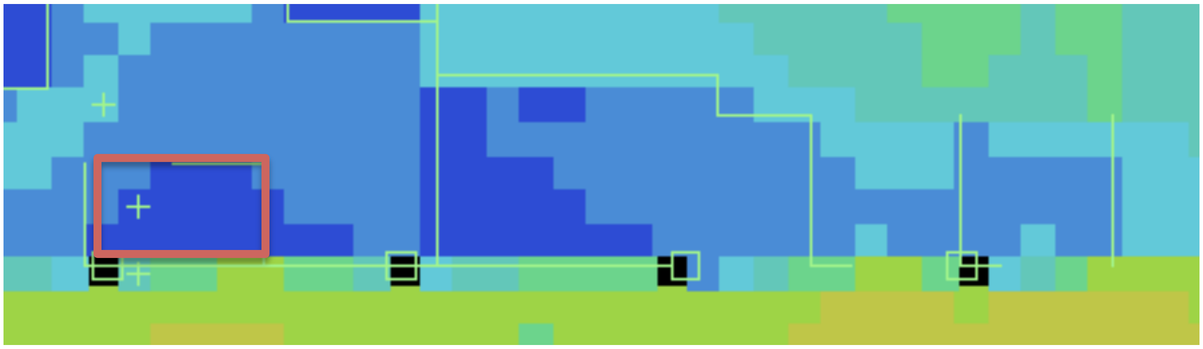

Figure 23: *Connectivity Heat Map, Identified Workspace has Low Connectivity* (rating 57)

6.1.9 Integration

Integration, a global measure of accessibility, varied significantly between spaces. The minimum rating for integration was 1.969, and the maximum was 5.095. An example of a workspace that is rated low on integration, and one rated high on integration, are provided in FIGURE 24 and 25, respectively. These are relative measures, based on the floorplan that was analyzed. The average integration rating was 3.36 (SD=0.82), and a median of 3.078.

Different floors, as well as different office types, had different levels of integration (discussed in section 6.3 ANOVA).

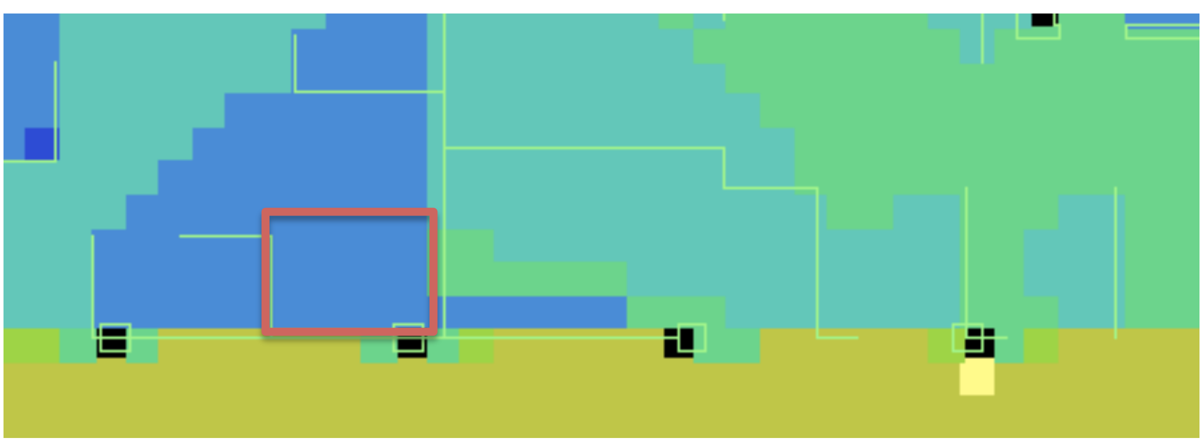

Figure 24: *Integration Heat Map, Identified Workspace has Low Integration (*rating 2.73)

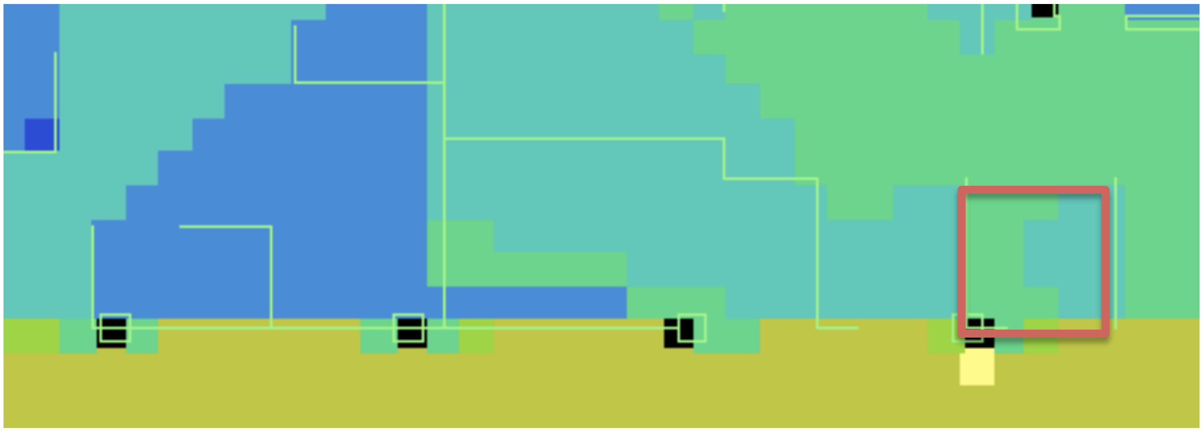

Figure 25: *Integration Heat Map, Identified Workspace has High Integration (*rating 3.98)

6.2 ACTIGRAPH SAMPLE DESCRIPTIVE STATISTICS

6.2.1 ActiGraph Participant Demographics

A total of 40 participants both wore ActiGraph meters and answered surveys. Again, females represented a significant majority of participants (78%, n=31).

Participants' ages were fairly evenly distributed, with 5% (n=2) aged between 25 and 29, 13% (n=5) between 30 and 34, 15% (n=6) between 35 and 39, 5% (n=2) between 40 and 44 , 13% (n=5) between 45 and 49, 15% (n=6) between 50 and 54, 18% (n=7) between 55 and 59, 13% (n=5) between 60 and 64, and 5% (n=2) aged over 65.

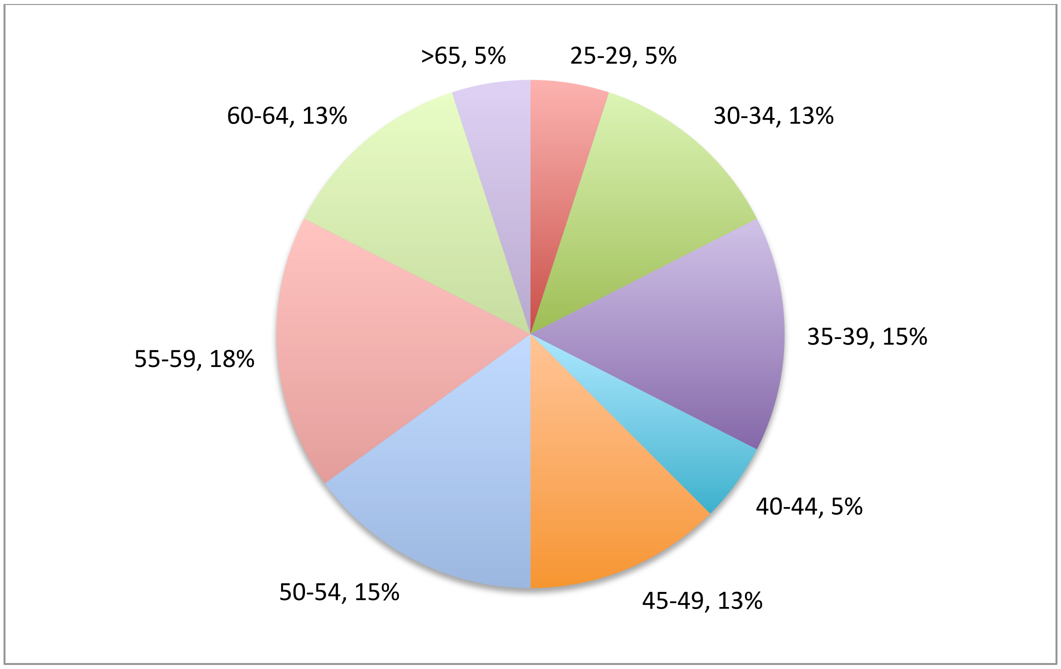

Figure 26: *Age (Actigraph Sample)*

Table 19
Gender and Age (Actigraph Sample)

	n	%
Gender		
Male	9	23%
Female	31	78%
Age		
18-24	0	0%
25-29	2	5%
30-34	5	13%
35-39	6	15%
40-44	2	5%
45-49	5	13%
50-54	6	15%
55-59	7	18%
60-64	5	13%
>65	2	5%

Nearly two thirds of the participants (63%, n=25) weighed less than 160 pounds. Eight percent of the individuals (n=3) weighed less than 120 pounds, and fifty-five percent of the participants (n=28) weighed between 120 and160 pounds. Five percent (n=2) weighed more than 220 pounds.

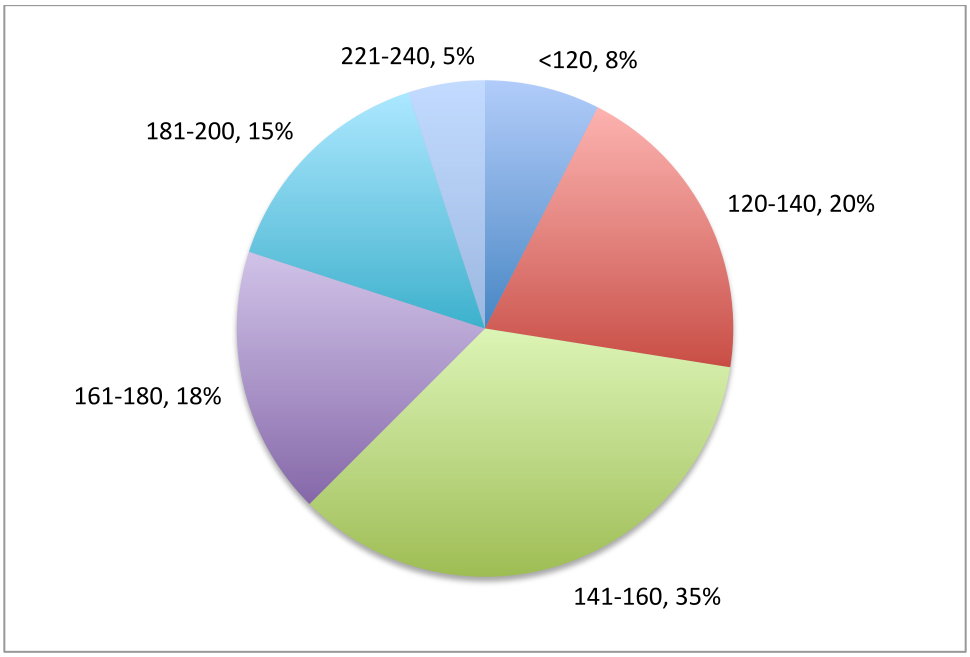

Figure 27: *Weight (Actigraph Sample)*

The average body mass index score (BMI) was 25.76 (standard deviation 4.08), which indicates that the average lies barely in the 'overweight' category. The minimum, median, and maximum BMI were 21, 24.5, and 40, respectively. Using the guidelines of BMI<25 as healthy weight, 25<BMI<30 as overweight, 30<BMI<39 as obese, and >39 as extremely obese, 48% (n=19) of the participants were of healthy weight, 33% (n=13) were overweight, 13% (n=5) were obese, and 3% (n=1) were extremely obese.

This sample had a slightly lower average BMI than the average American (BMI=26.6 for men and 26.5 for women). Fewer individuals in the sample were obese than the national average, as approximately 34.9% of Americans are obese (CDC). Slightly fewer individuals were obese in this sample than the New York state average of 25.4%.

Table 20
Weight and BMI

	n	%
Weight		
<120	3	8%
120-140	8	20%
141-160	14	35%
161-180	7	18%
181-200	6	15%
201-220	0	0%
221-240	2	5%
>240	0	0%
BMI		
Healthy <25	19	48%
Overweight 25-29	13	33%
Obese 30-39	5	13%
Extremely Obese 40+	1	3%

A majority (88%, n=35) of participants were of white/Caucasian race, with 5% (n=2) Asian, and 3% (n=1) were Hispanic and 'Other'.

Over two-thirds (68%, n=27) of the participants reported that their job roles were "Administration/Support". The remaining participants indicated that they were Management (13%, n=5), Research Staff (13%, n=5), Technician (5%, n=2), and Faculty (3%, n=1).

Sixty-eight percent of the participants (n=27) had received a bachelors degree or higher, with 38% (n=15) receiving a Bachelor's degree and 30% (n=12) receiving Postgraduate degrees.

Thirteen percent (n=5) received an Associates degree, and 13% (n=5) attended some college. Eight percent (n=3) indicated that they graduated from high school and that this was the highest level of education they had received.

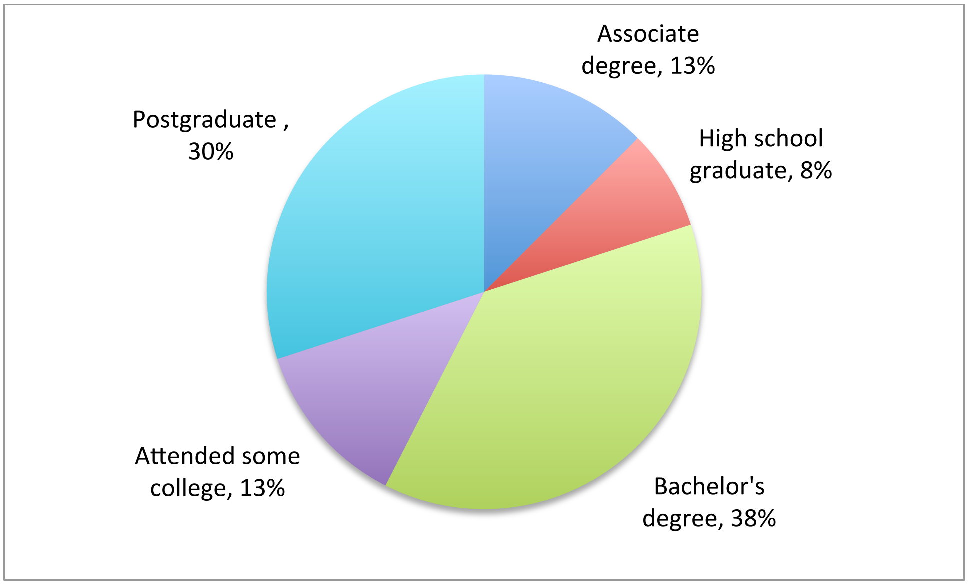

***Figure 28**: Education (Actigraph Sample)*

Table 21
Race, Education, and Position

	n	%
Race		
White	35	88%
Black/African American	0	0%
Asian	2	5%
Native Hawaiian/Pacific Islander	0	0%
Hispanic	1	3%
American Indian/Alaska Native	0	0%
Other	1	3%
Education		
Some high school or less	0	0%
Associate degree	5	13%
High school graduate	3	8%
Bachelor's degree	15	38%

Attended some college	5	13%
Postgraduate	12	30%
Position		
Faculty	1	3%
Undergraduate Student	0	0%
Technician	2	5%
Post Doc	0	0%
Research Staff	5	13%
Management	5	13%
Graduate Staff	0	0%
Administration/Support	27	68%

More than four out of five participants (86%, n=34) indicated that they were in overall good or very good health (53% ‘Good’, 33% ‘Very Good’). Thirteen percent (n=5) indicated that they were in overall fair health, and 3% (n=1) indicated they were in poor health. Seven out of ten (70%, n=28) participants reported that they got less exercise than they needed, and three out of ten (30%, n=12) believed they got as much exercise as they needed.

Table 22
Self-Reported Health and Exercise

	n	%
Overall Health		
Very Good	13	33%
Good	21	53%
Fair	5	13%
Poor	1	3%
Very Poor	0	0%
Don't Know	0	0%
Enough Exercise		
As much as I need	12	30%
Less than I need	28	70%

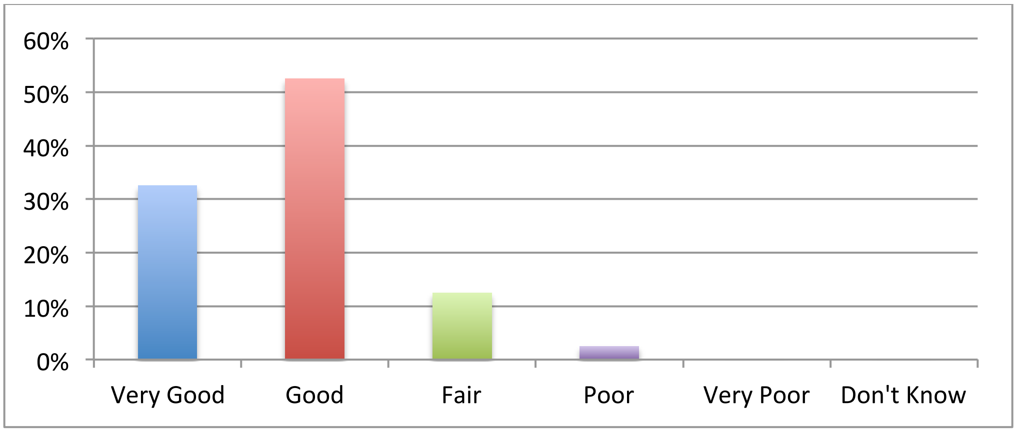

Figure 29: *Overall Health (Actigraph Sample)*

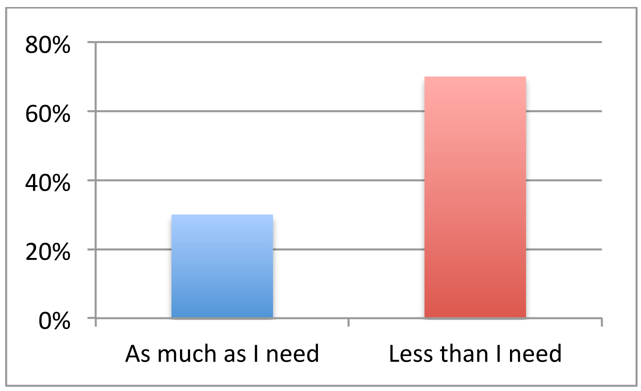

Figure 30: *Amount of Exercise (Actigraph Sample)*

The average number of hours worked per day was 8.36 (standard deviation=1.14), and the average number of hours worked per week was 42.35 (standard deviation=6.83). The median number of hours worked per day was eight and the median number of hours per week 40. Of the hours worked per week, participants reported that they spent an average of 41.075 hours in the buildings of study (standard deviation=3.52).

Figure 31: *Average Hours Worked per Day (Actigraph Sample)*

Figure 32: *Average Hours Worked Per Week (Actigraph Sample)*

Seventy percent of the participants had worked in the building for over two years, and 68% had worked in their particular office/workstation for over two years. The minimum time that an individual had worked or worked in a workspace in the building was 1.5 months, the maximum time that an individual had worked in the building was 30 years, and the maximum time that an individual had worked in their particular workstation was 28 years 11 months. The average length of time that the participants had worked in the building was 8 years 6 months (SD=8.65yr), and the average length of time that the participants had worked in their particular workstation was 5 years 9 months (SD=7.04yr). The median length of time that the participants had worked in the building was 5 years 6 months, and the median length of time that the participants had worked in their particular workstations was 3 years 10 months.

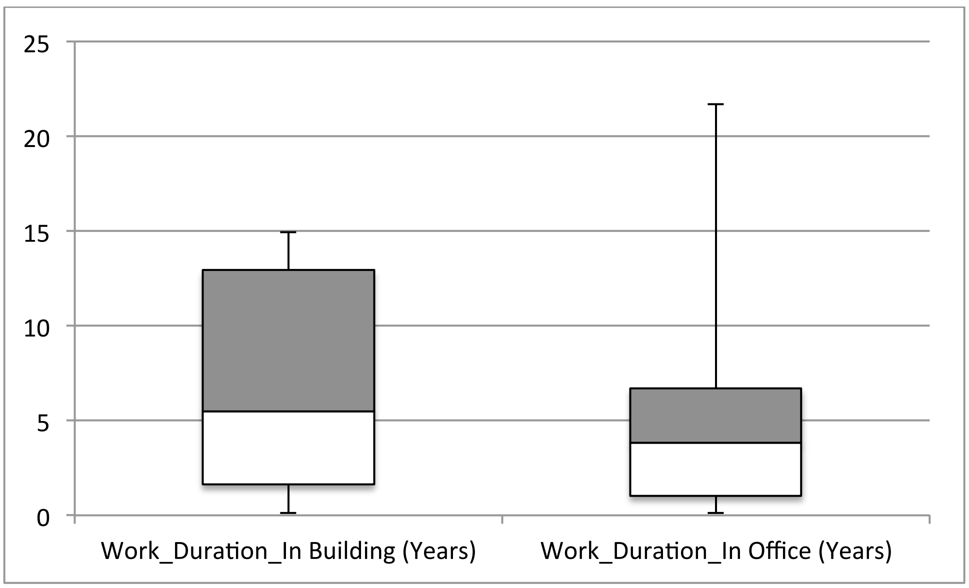

Figure 33: *Years Worked in Building and in Present Workspace (Actigraph Sample)*

6.2.2 ActiGraph Participants, Section 1: Physical Activity

6.2.2.1. Physical Activity at Work

Eighteen percent of participants indicated that they engaged in 10 minutes of continuous vigorous physical activity *as a part of their work* on at least 1 day of the week, while 53% indicated that they did not perform 10 minutes of continuous vigorous PA on any days as part of their work. Of the seven individuals who performed 10 minutes of continuous vigorous PA on at least one day, four also reported the average amount of time that they spent per day performing vigorous physical activity as part of their work; the average was 22.5 minutes (SD=29.28) with a maximum of 60 minutes.

Eight percent of participants indicated that they engage in 10 minutes of continuous moderate PA *as a part of their work* on at least 1 day per week, and 63% indicated that they did not perform 10 minutes of continuous moderate PA on any days as part of their work. Of the three individuals who reported the average amount of time that they spent per day performing moderate physical activity as part of their work, the average was 8.75 minutes (SD=6.29) with a maximum of 15 minutes.

Twenty five percent of participants indicated that they engaged in 10 minutes of continuous walking *as a part of their work* on at least 1 day of the week, while 50% indicated that they did not perform 10 minutes of continuous walking on any days as part of their work. Of the 14 individuals who reported the average amount of time that they spent per day walking as part of their work the average was 31.6 minutes (SD=30.75) with a maximum of 120 minutes.

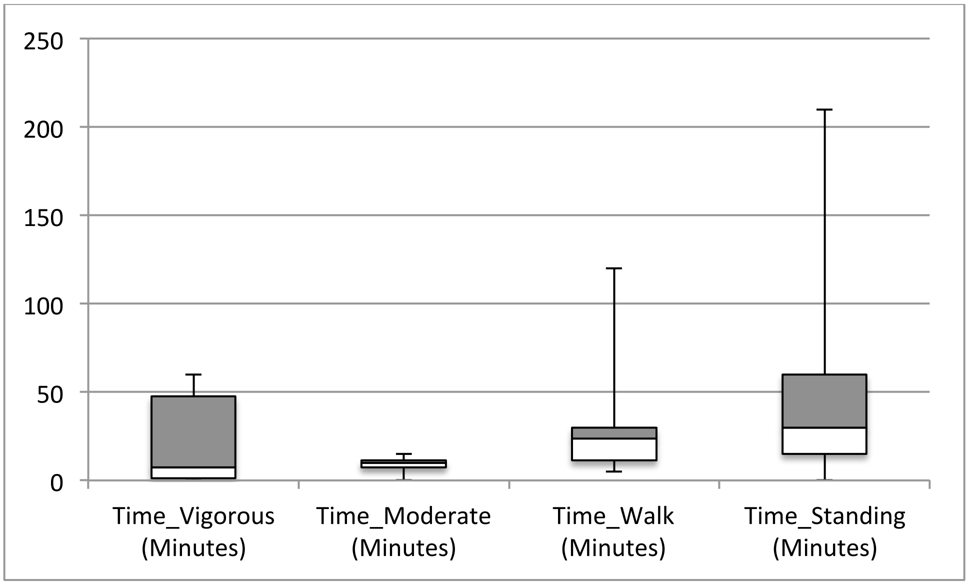

Figure 34: *Self-Reported Average Minutes per Day Engaged in Various Activities At Work (Actigraph Sample)*

Individuals reported sitting for an average of 7.26 hours per day (SD=1.13) and standing for an average of 38.44 minutes (.64 hours) per day (SD=38.44). Five percent (n=2) of the participants reported that they did not stand as a part of their work.

Figure 35: *Self-Reported Average Hours per Day*

Sitting At Work (Actigraph Sample)

Table 23
Self-reported Activity at Work

	Min/Max	Average (SD)	Median
Vigorous activity at work			
No. of days per week	0/7	0.79 (1.73)	0
Ave. no. min/day	0/60	22.50 (29.28)	7.5
Moderate activity at work			
No. of days per week	0/7	0.54 (1.67)	0
Ave. no. min/day	0/15	8.75 (6.29)	10
Walking at work			
No. of days per week	0/6	1.27 (2.10)	0
Ave. no. min/day	0/120	31.60 (30.75)	23.75
Standing at work			
Ave. no. min/day	0/210	38.44 (41.20)	30
Sitting at work			
Ave. no. hours/day	4/10	7.26 (1.13)	7.5

6.2.2.2 Total Physical Activity

Participants were asked to indicate the number of days per week that they engaged in at least 30 minutes of moderate physical activity *at any point in the day*. More than half of the participants (58%) indicated that they engaged in 30 minutes of moderate PA on three days per week or less, with 23% engaging on three days per week, 13% engaging on only one day per week, and 23% engaging on no days per week (0 days per week).

Forty three percent of participants engaged in at 30 minutes of moderate PA on at least 4 days per week, with 33% engaging in 30 minutes of moderate PA on at lest 5 days per week, and 8% engaging on all seven days. The average number of days/week that participants engaged in 30 minutes of moderate PA was 3.1 (standard deviation=2.36). The median was also 3 days per week.

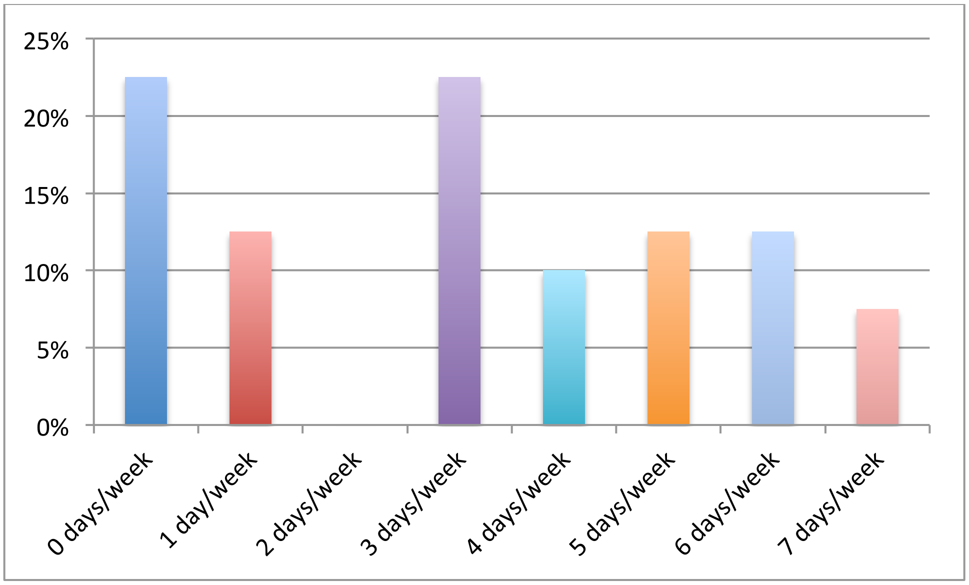

Figure 36: *Average Number of Days per Week Engaged in 30 Minutes of Moderate Physical Activity at Any Point in the Day (Actigraph Sample)*

Participants were also asked to indicate the number of days per week that they engaged in at least 10 minutes of walking *at any point in the day*. Nearly half of participants (48%) indicated that they engaged in 10 minutes of walking on three days per week or less, with 23% engaging on three days per week, 3% engaging on 2 days per week, 10% engaging on only one day per week, and 13% engaging on no days per week (0 days per week).

Forty five percent of participants engaged in 10 minutes of walking on at least four days per week, with 38% engaging in 10 minutes of walking on at lest 5 days per week, and 13% engaging on all seven days. The average number of days/week that participants engaged in 10 minutes of walking was 3.54 (standard deviation=2.23). The median was 3 days per week.

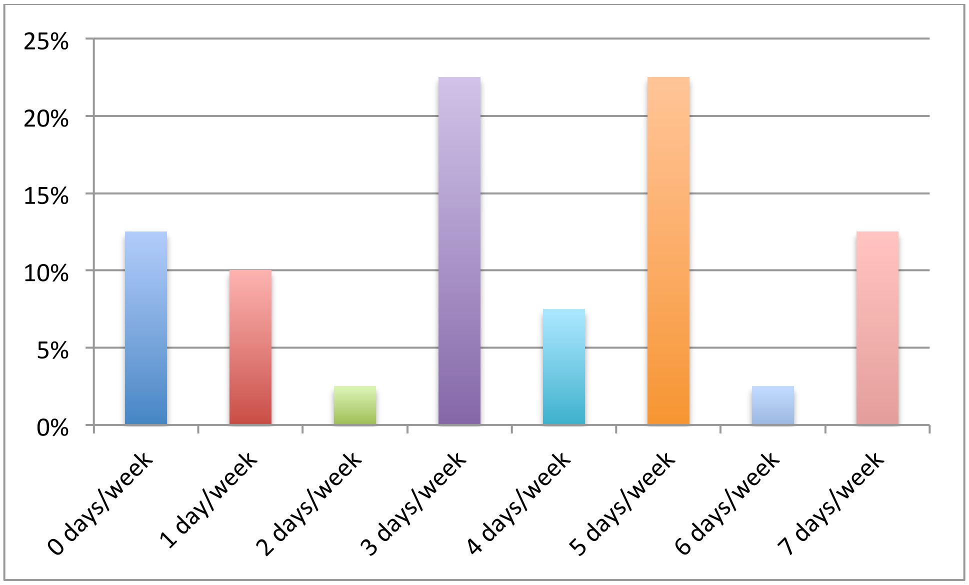

Figure 37: *Average Number of Days per Week Engaged in 10 Minutes of Walking at Any Point in the Day (Actigraph Sample)*

Table 24
Average No. of Days/Week Engaged in Moderate PA or Walking at Any Point in the Day (Actigraph Sample)

	%	N
No. days/week engaged in 30 minutes of moderate PA		
0 days/week	23%	9
1 day/week	13%	5
2 days/week	0%	0
3 days/week	23%	9
4 days/week	10%	4
5 days/week	13%	5
6 days/week	13%	5
7 days/week	8%	3
No. days/week engaged in 10 minutes of walking		
0 days/week	13%	5
1 day/week	10%	4
2 days/week	3%	1
3 days/week	23%	9
4 days/week	8%	3

5 days/week	23%	9
6 days/week	3%	1
7 days/week	13%	5

6.2.3 ActiGraph Participants, Section 2: Satisfaction

Individuals were asked to rate their job satisfaction, their satisfaction with the spatial environment of the workplace, and whether the spatial environment supports their ability to perform work based on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree.

No individuals were strongly dissatisfied with their job, and only 8% (n=3) were dissatisfied with their job. Eleven percent of respondents (n=4) reported they were neutral about their job satisfaction. Eighty two percent (n=30) of respondents were either satisfied or very satisfied with their jobs, with 49% (n=18) being satisfied and 32% (n=12) being very satisfied. The average job satisfaction rating was 4.05, or slightly above satisfied.

Twenty-three percent of respondents were dissatisfied to some extent with the spatial environment of their workplace; five percent of respondents (n=2) reported they were very unsatisfied with the spatial environment and 18% (n=7) reported they were unsatisfied. Eighteen percent of respondents (n=7) reported they felt neutral about the spatial environment. Fifty-eight percent (n=22) of respondents reported being satisfied to some extent with the spatial environment, with 34% (n=13) reporting they were satisfied and 24% (n=9) reporting they were very satisfied. The average spatial environment satisfaction rating was 3.52, in between neutral and satisfied.

No individuals reported that the spatial environment strongly interfered with their ability to perform work, however 5% (n=2) of respondents felt that the spatial environment interfered with their ability to perform work. Twenty-one percent of respondents (n=8) felt neutral about the effect of the spatial environment on their performance. Seventy-four percent of respondents felt that the spatial environment supported their ability to do work to some extent, with 21% (n=8) reporting that they felt the spatial environment strongly supported their ability to perform work. The average rating for support from the spatial environment was 3.89, or just below the level of satisfied.

Table 25
Job and Spatial Satisfaction

	%
Job Satisfaction	
Very Dissatisfied	0%
Dissatisfied	8%
Neutral	11%
Satisfied	49%
Very Satisfied	32%
Satisfaction with the spatial Environment	
Very Dissatisfied	5%
Dissatisfied	18%
Neutral	18%
Satisfied	34%
Very Satisfied	24%
Spatial environment supports ability to perform work	
Strongly Disagree	0%
Disagree	5%
Neutral	21%
Agree	53%
Strongly Agree	21%

Individuals were asked to indicate how frequently they experienced a variety of feelings while at work based on a 5-point Likert scale where 1=Always 2=Daily 3=Several times/week 4=Seldom and 5=Never.

Sixty-nine percent (n=26) of respondents reported feeling fatigued either seldom or never. Twenty-one percent reported feeling fatigued several times per week, and only 8% (n=3) reporting that they felt fatigue daily.

Fifty-six percent (n=21) reported feeling sleepiness seldom or never; 29% (n=11) reported feeling sleepiness several times per week, and only 16% (n=6) reported feeling sleepy on a daily basis.

Five percent (n=2) reported feeling stressed ‘always,’ and 21% (n=8) reported feeling stressed on a daily basis. Thirty-one percent (n=12) reported feeling stressed several times per week, and 44% percent (n=17) of respondents reported feeling stressed seldom or never.

A majority (59%, n=23) of respondents reported feeling irritable seldom or never. Thirty-one percent (n=12) reported feeling irritable several times per week, five percent (n=2) reported feeling irritable daily, and five percent (n=2) reported feeling irritable ‘always.’

Only eight percent (n=3) of respondents reported getting headaches ‘always’ or daily, and 10% (n=4) reported getting headaches several times per week. Eighty-two percent (n=32) reported getting headaches either seldom or never.

A majority of the respondents (68%, n=27) reported feeling in a good mood at least daily. Twenty-eight percent (n=11) reported feeling in a good mood several times per week, and only 3% (n=1) reported that they were seldom in a good mood.

Table 26
Frequency of Experiencing Various Feelings at Work

	Always	Daily	Several Times/Week	Seldom	Never
Feeling					
Unusual Fatigue	0%	8%	21%	53%	16%
Sleepiness	0%	16%	29%	53%	3%
Stress	5%	21%	31%	41%	3%
Irritability	5%	5%	31%	51%	8%
Headaches	3%	5%	10%	56%	26%
Good mood	5%	63%	28%	3%	0%

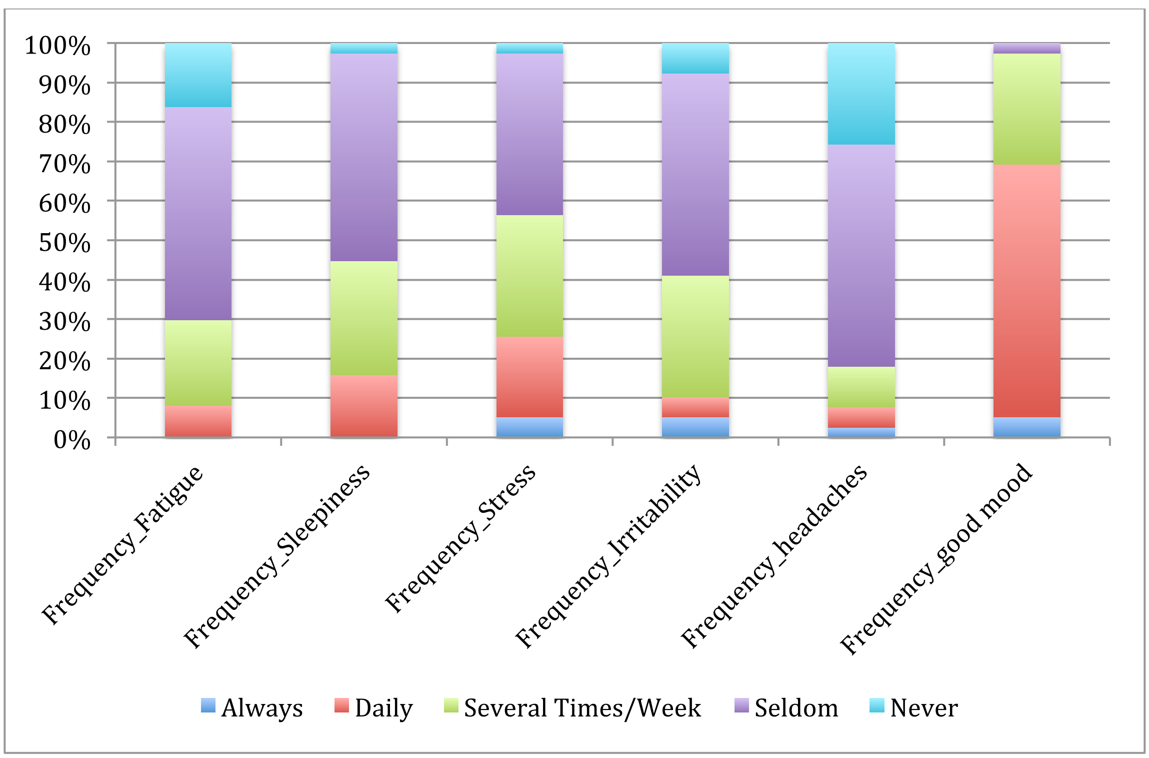

Figure 38: *Frequency of Experiencing Various Feelings at Work (Actigraph Sample)*

6.2.4 Staircases and Elevators

Only one of the study sites, building 1, was a multi-level building. For this reason, the following questions regarding staircases and elevators in the building were not evaluated for the participants of building 2. The sample includes the 26 participants in building 1 who also wore the Actigraph accelerometer.

Individuals were asked to indicate the number of times that they walk the stairs during a typical workday as well as the total number of stories walked. On average, individuals reported walking the stairs 4.85 times (SD=4.20), with a minimum of one time, a maximum of 20 times, and a median of 3.75 times per day. On average individuals walked a total of 5.06 flights of stairs per day (SD=7.88), with a minimum of one flight, a maximum of 40 flights, and a median of 3 flights per day.

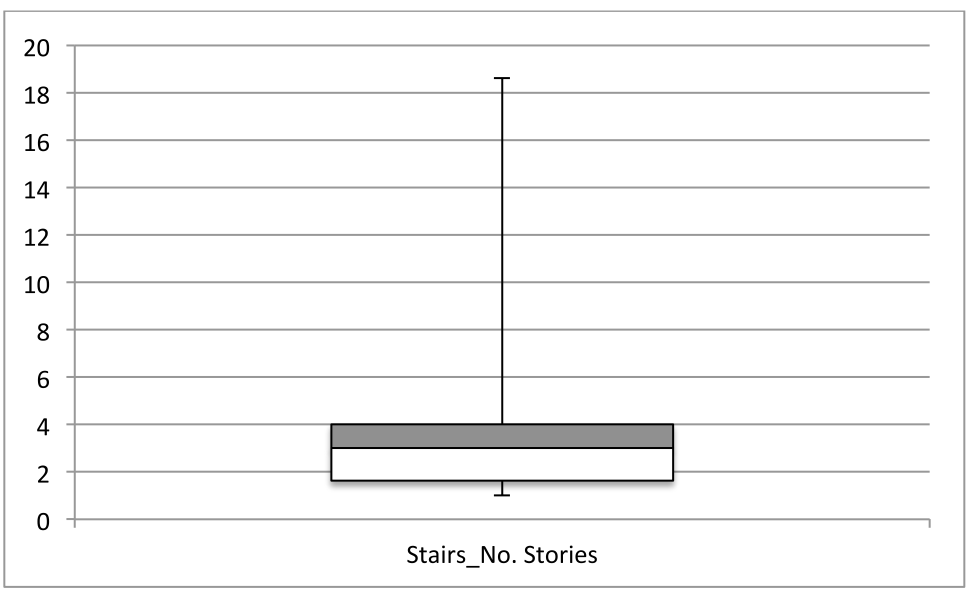

Figure 39: *Average Number of Stores Climbed by Stairs per Day (Actigraph Sample)*

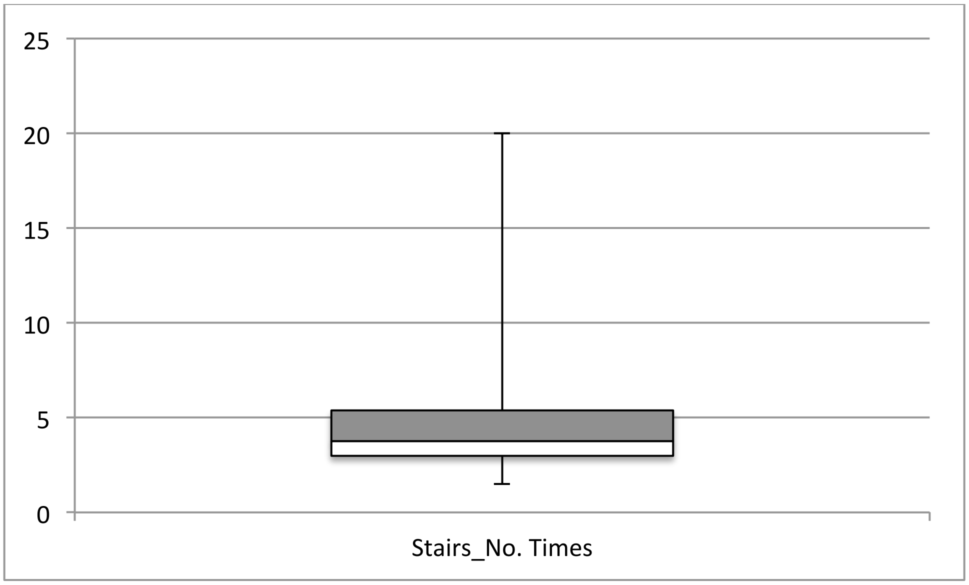

Figure 40: *Average Number of Times Stairs are Used per Day (Actigraph Sample)*

More than four out of five respondents (85%, n=22) reported that their preferred method of vertical transportation was the stairs, and the remaining 15% (n=4) noted that it depends on the number of flights of stairs. Of those four individuals who reported that their use of the stairs depended on the number of flights to ascend or descend, two reported that they would use the stairs if it was less than three flights, and two reported they would use the stairs if it was less than four flights.

Individuals were asked to report the factors that influenced their stair use. The most frequently reported influence was exercise (46%, n=12). Number of floors to travel and a preference for stairs were both reported by 15% of the sample (n=4), and direction of travel, time-related pressure from work, and time spent waiting for elevator were each reported by 8% (n=2).

Individuals were asked to report the factors that influenced their elevator use. The most frequently reported influence was carrying heavy things, which was reported by 56% of participants (n=14). Other frequently mentioned influences on elevator use include Injury or health problems (20%, n=5), to avoid getting sweaty or out of breathe (4%, n=1), and convenient (4%, n=1).

Individuals were asked to report the factors that encouraged them to walk the stairs. The most frequently reported factor that encouraged walking the stairs was exercise, reported by 42% of the sample (n=11). Other frequently mentioned factors include Staircase close to building entrance (31%, n=8), Motivated by friends/colleagues who I walk with (15%, n=4), The look and feel of the stairs (8%, n=2), and Staircase lit by natural daylight (8%, n=2).

Table 27
Influences on Stair and Elevator Use

	N	%
First choice for vertical travel		
Elevator	0	0%
Stairs	22	85%
Depends on the number of floors	4	15%
3	2	8%
4	2	8%
Main influence on stair use		
Direction of Travel	2	8%
Time-related pressure from work	2	8%
Crowdedness of Elevator	0	0%
Number of floors to travel	4	15%
Time spent waiting for elevator	2	8%
Speed of elevator	1	4%
Other, please specify	19	73%
Main influence on elevator use		
Convenient	1	4%
Carrying heavy things	14	56%
The perception of not being fit	0	0%

enough to climb stairs		
The perception that stairs are too far to reach the destination	0	0%
To avoid getting sweaty or out of breath	1	4%
Laziness	0	0%
Injury or health problems	5	20%
Other, please specify	4	16%
Factors encouraging you to walk stairs		
The look and feel of the stairs	2	8%
Staircase lit by natural daylight	2	8%
Motivated by friends/colleagues who I walk with	4	15%
Staircase close to building entrance	8	31%
Motivating signage	0	0%
Other, please specify	18	69%

Satisfaction with various aspects of elevator and stairwell design and maintenance are included below. These questions were answered on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree. Both descriptive statistics (min, average, standard deviation, median, and max) as well as percentage counts are provided for each variable.

Table 28
Elevator and Stairwell Measures

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The staircase entrance(s) are visible from where I enter the building.	0%	12%	8%	27%	54%
The elevator(s) are visible from where I enter the building.	4%	23%	8%	27%	38%
The staircase(s) are easily accessible from my office/cubicle.	0%	4%	8%	31%	58%
The elevator(s) are easily accessible from my office/cubicle.	0%	4%	8%	28%	60%
The elevator waiting time is long.	12%	15%	31%	23%	19%

The staircase(s) are safe to walk.	0%	0%	8%	27%	65%
The staircase(s) look pleasant.	0%	23%	50%	12%	15%
I talk to colleagues often when I walk stairs.	12%	27%	31%	27%	4%
The staircase is located along the primary path of my travel.	0%	4%	23%	38%	35%
The staircase entrance(s) are visible from elevator waiting area.	0%	0%	4%	42%	54%
The stair entry door(s) exist.	0%	0%	0%	35%	65%
The staircase is well maintained.	0%	0%	8%	50%	42%
The stair entry door(s) are often held open.	35%	27%	8%	15%	15%
I am comfortable with the height of step.	0%	0%	8%	38%	54%
I am comfortable with the temperature in staircase(s).	0%	0%	4%	50%	46%
There is natural daylight in staircase.	58%	19%	4%	19%	0%
Daylight in the staircase encourages me to use stairs.	28%	0%	52%	16%	4%
The staircase is wide enough for short conversations to take place.	4%	12%	23%	54%	8%
The staircase is clean.	0%	4%	4%	64%	28%
I have short conversations with my colleagues when I walk stairs.	8%	27%	35%	23%	8%

6.2.5 Layout impact

Individuals were asked to rate the extent to which they agreed or disagreed with several statements relating to interactive behavior in the workspace, because this is a possible reason that office workers get out of their chairs. Responses were given on a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree.

Table 29: Meeting Space Variables					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There is enough space in my office/cubicle to hold a face-to-face meeting.	12%	5%	7%	49%	27%
There is appropriate furniture (e.g., table, guest chair, power outlet, etc.) for meetings in my office/cubicle.	20%	5%	7%	44%	24%
There are different-sized meeting rooms/spaces on the floor where I am working.	12%	15%	0%	49%	24%
The arrangement and furnishing of the meeting rooms/spaces supports meeting effectiveness.	0%	3%	29%	50%	18%

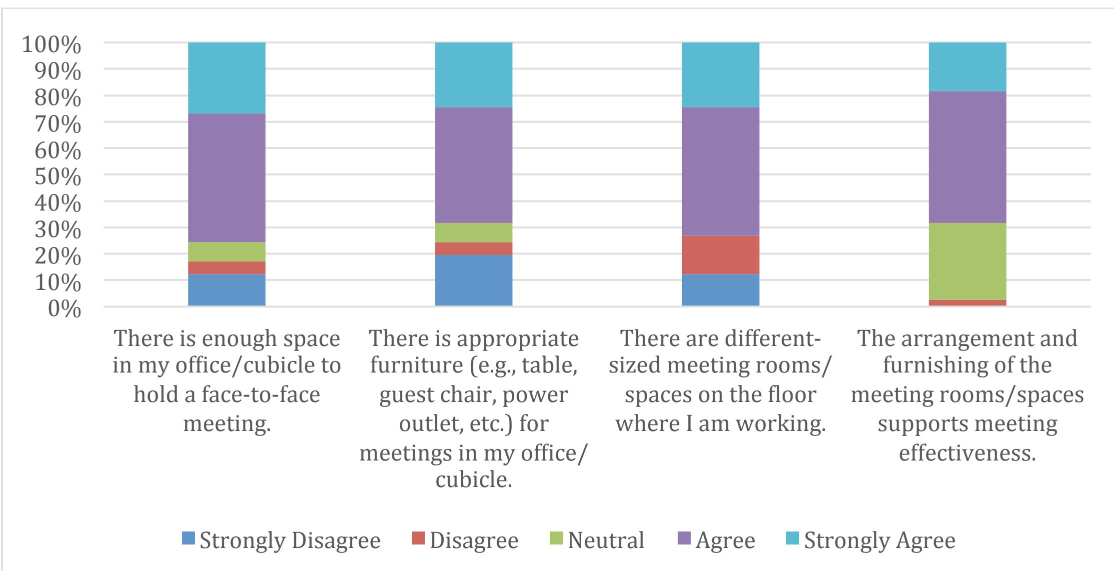

Figure 41: *Meeting Space Variables (Actigraph Sample)*

Participants were asked to rank the main factors that influence their choice of meeting space. Five options were provided, as well as an “Other, Please specify” option. Participants ranked their choices using number 1-5, or 1-6 if they chose to fill in the “Other” item. The five options that were provided were: Room capacity, Furniture, Technology, Distance to my office/cubicle, and Room with window(s). Only the 24 individuals who ranked all five (or six) items have been included in this analysis; eight of these individuals filled in the "Other" item.

Overall, Room capacity was the most important factor in choosing a meeting room, being ranked first 71% of the time (n=17), and second 25% of the time (n=6). Technology and distance to office were the next factors most frequently rated first (4%, n=1). The least important factors were Rooms with windows, which was ranked fifth 54% of the time, and Distance to office, which was ranked fifth 33% of the time.

Table 30
Factors Influencing Meeting Room Choice

	Ranked First	Ranked Second	Ranked Third	Ranked Fourth	Ranked Fifth	Ranked Sixth
Room Capacity	71%	25%	0%	0%	4%	0%
Furniture	4%	13%	38%	42%	0%	4%
Technology	0%	33%	58%	4%	4%	0%
Distance to office	4%	17%	0%	25%	33%	21%
Room with Windows	0%	4%	4%	29%	54%	8%
Other	21%	4%	0%	4%	4%	0%

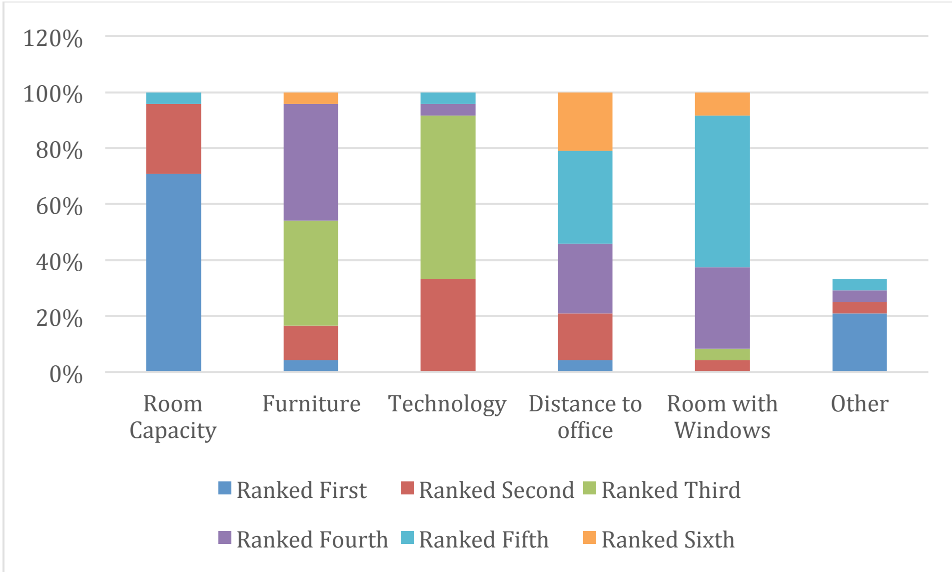

Figure 42: *Variables That Impact Meeting Room Choice (Actigraph Sample)*

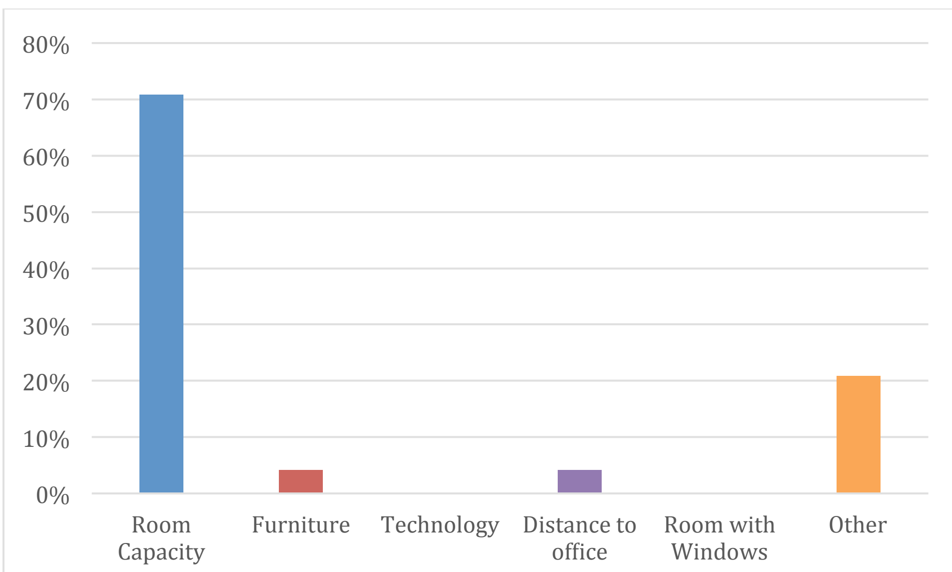

Figure 43: *Percent of Time Variables Were Ranked as Most Important Influence on Choice of Meeting Room (Actigraph Sample)*

Individuals were asked how often they take a walk during their lunch or other break time, and were asked to respond on a 5-point Likert scale with scales 1=Never, 2=Seldom, 3=Sometimes, 4=Often, or 5=Always. The majority of people (76%, n=31) walk “Sometimes” or more frequently, and only 24% (n=10) seldom or never walk on their breaks.

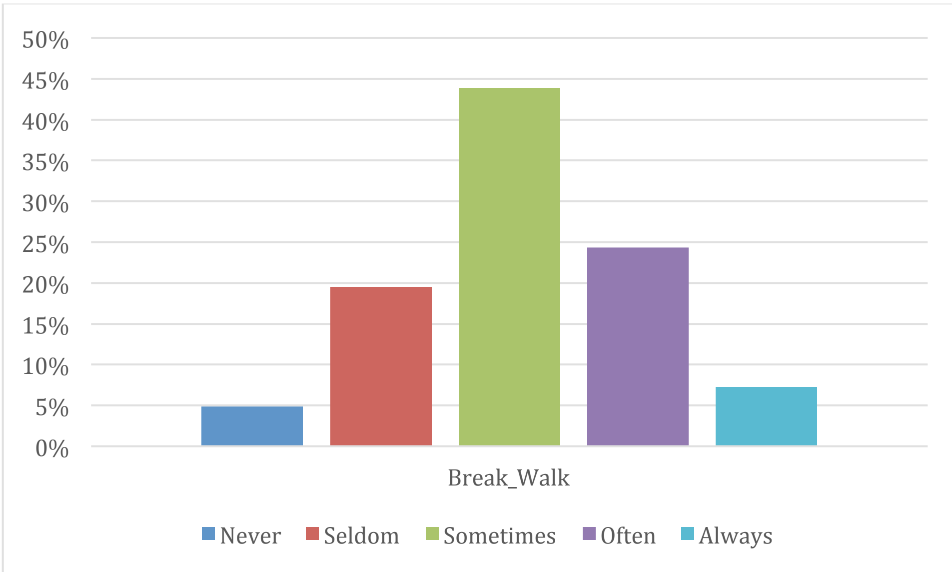

Figure 44: *Frequency of Walking During Breaks (Actigraph Sample)*

Individuals were asked whether they disagreed or agreed with the following two statements: “Do you think workplace technology (e.g., email, internet messengers, etc.) increases your sedentary behavior?” and “Do you prefer email or instant message to talking in person with your colleagues?” Responses were measured using a 5-point Likert scale where 1=Strongly Disagree 2=Disagree 3=Neutral 4=Agree and 5=Strongly Agree.

The majority of individuals (88%, n= 36) agree or strongly agree that workplace technology increases sedentary behavior, and only 7% (n=3) disagree or strongly disagree. Thirty-seven percent (n=15) of individuals prefer or strongly prefer email or instant message to talking in person, while 39% (n=16) prefer talking in person.

Table 31
Workplace Habits

	%
Frequency of walking during lunch or other break	
Never	5%
Seldom	20%
Sometimes	44%
Often	24%
Always	7%
Workplace technology increases your sedentary behavior	
Strongly Disagree	2%
Disagree	5%
Neutral	5%
Agree	29%
Strongly Agree	59%
Prefer email or IM to talking in person	
Strongly Disagree	12%
Disagree	27%
Neutral	24%
Agree	32%
Strongly Agree	5%

6.2.6 Distance Measures

6.2.6.1 Self-reported Distance Measures

Individuals were asked to report the number of times they visit various amenity spaces in a typical day, including meeting rooms, printing/copy area, mail room, coffee/break room, restroom; these results are presented in table 32. Individuals were also asked to estimate the distance between their workspace and these amenity spaces, shown in table 33.

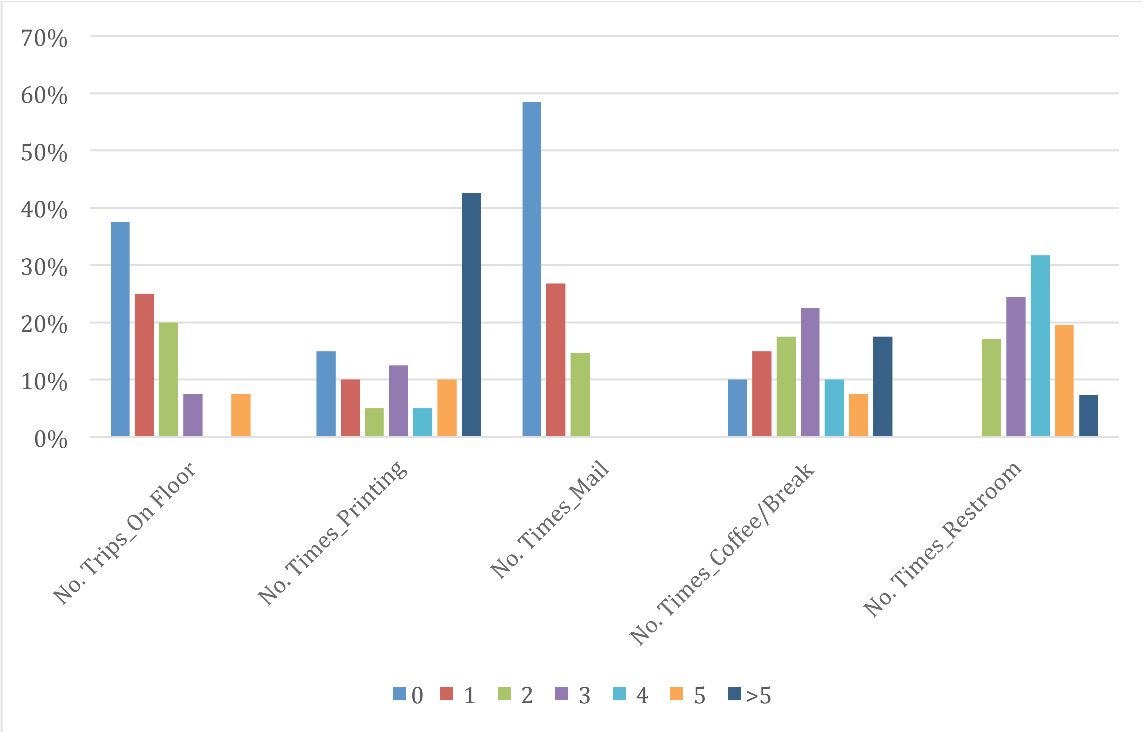

Figure 45: *Average Number of Times per Day Participants Visit Various Amenity Spaces (Actigraph Sample)*

Table 32
Average Number of Times per Day Participants Visit Various Amenity Spaces

	0	1	2	3	4	5	>5
Ave. no. of times per day visiting:							
Meeting room	38%	25%	20%	8%	0%	8%	0%
Printer/copier	15%	10%	5%	13%	5%	10%	43%
Mail Room	59%	27%	15%	0%	0%	0%	0%
Coffee/break area	10%	15%	18%	23%	10%	8%	18%
Restroom	0%	0%	17%	24%	32%	20%	7%

Table 33
Self-Reported Distance From Workspace to Various Amenity Spaces

	Min/Max	Average (SD)	Median
Distance, in feet, from workspace to:			
Meeting room	5/150	41.4 (35.98)	30
Printer/copier	1/100	20.92 (20.37)	15
Mail room	1/275	52.37 (56.89)	40
Coffee/break area	4/200	47.47 (38.7)	40.5
Restroom	10/200	56.11 (40.64)	45

6.2.6.2 Objectively Measured Distance

Objective distance measures were also taken from the center of participants' workspaces to the center of the following amenity spaces: restroom, meeting room, printer/copier, and coffee/break area. On average, individuals were 133.39 feet from restrooms, 92.46 feet from meeting rooms, 47.73 feet from printer/copier, and 90.33 feet from coffee/bar area.

Table 34
Objectively Measured Distance from Workspaces to Amenity Areas

	Min/Max	Average (SD)	Median
Distance, in feet, from:			
Restroom (M/F)	65/338	133.39 (64.57)	122
Meeting Room	21/211	92.46 (45.75)	90
Printer/Copier	6/179	47.73 (51.73)	28
Coffee/Bar area	16/239	90.33 (65.01)	72

6.2.6.3 Comparison of Objectively Measured and Self-Report Distance Measures

Overall, the objective measurements were significantly higher than the self-reported distances, suggesting that participants significantly underestimated physical distances from their office to these shared spaces. Comparisons of average and median distances are provided below.

Table 35
Comparison of Objectively Measures and Self-Report Distances to Amenity Spaces

	Average (Self-Report)	Average (Objective Measure)	Median (Self-report)	Median (Objective Measure)
Distance, in feet, from:				
Restroom (M/F)	56.11	133.39	45	122
Meeting Room	41.40	92.46	30	90
Printer/Copier	20.92	47.73	15	28
Coffee/Bar area	47.47	90.33	40.5	72

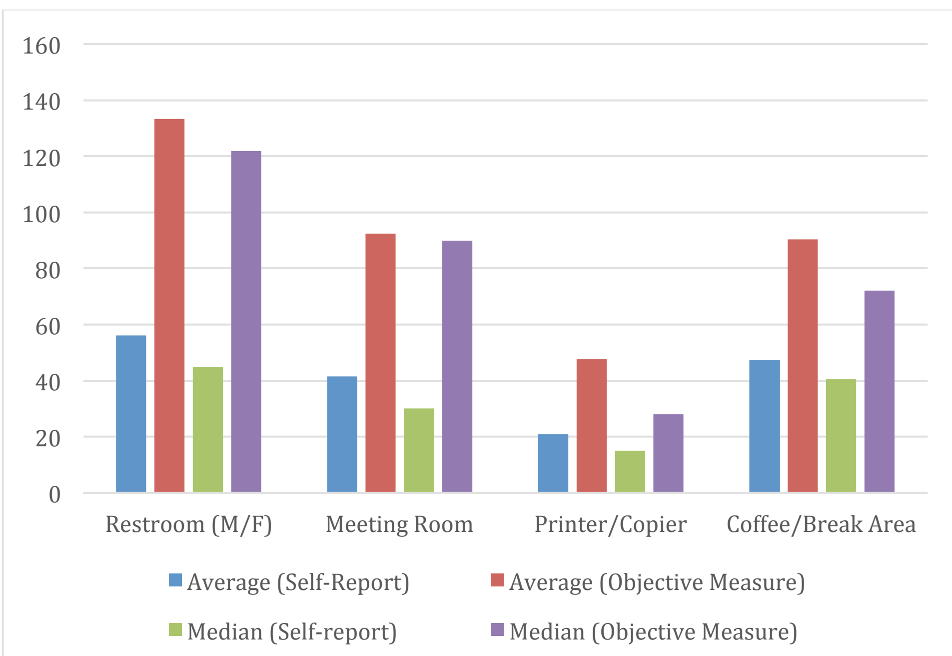

***Figure 46:** Comparison of Objectively Measures and Self-Report Distances to Amenity Spaces (Actigraph Sample)*

6.2.7 Work Limitations Questionnaire

Individuals who did not answer a sufficient number of questions to calculate the WLQ Productivity Loss Score were removed from analysis, resulting in a total of 41 valid WLQ responses.

Following the methodology set forth by Brown et al. (2013), employees were categorized according to their WLQ Index score, using cutoffs from the WLQ scoring documentation: less than 5% as no impairment, 5% to 10.9% as “mild impairment,” 11% to 16.9% as “moderate impairment,” and 17% to 100% as “severe impairment.” Given the small proportion of participants across moderate and severe conditions (2%), this variable was dichotomized into “no impairment” (WLQ Index score less than 5%) and “impairment” (WLQ Index score 5% or greater) for analyses.

The four WLQ subscale scores include the Time Management Scale, Physical Scale, Mental/Interpersonal Scale, and the Output Scale. These values of these scales are used to compute the WLQ Productivity Loss score. The WLQ Productivity Loss score is interpreted as the percentage of productivity loss in the past two weeks due to presenteeism relative to a healthy benchmark sample. The benchmark sample consists of employees who had WLQ scale scores of zero (not limited by health).

The average scores for the subscales were as follows: time management, 9.54%; physical demands 10.06%; mental/interpersonal demands, 11.25%; and output demands, 7.93%.

The average WLQ Productivity Loss score was 3% (SD=3%), with a minimum score of 0% (no impairment), maximum score of 13% (moderate impairment), and median score of 1% (no impairment). Eighty percent (n=33) of participants were categorized as having no impairment, 17% (n=7) were categorized as having mild impairment, and 2% (n=1) were categorized as having moderate impairment.

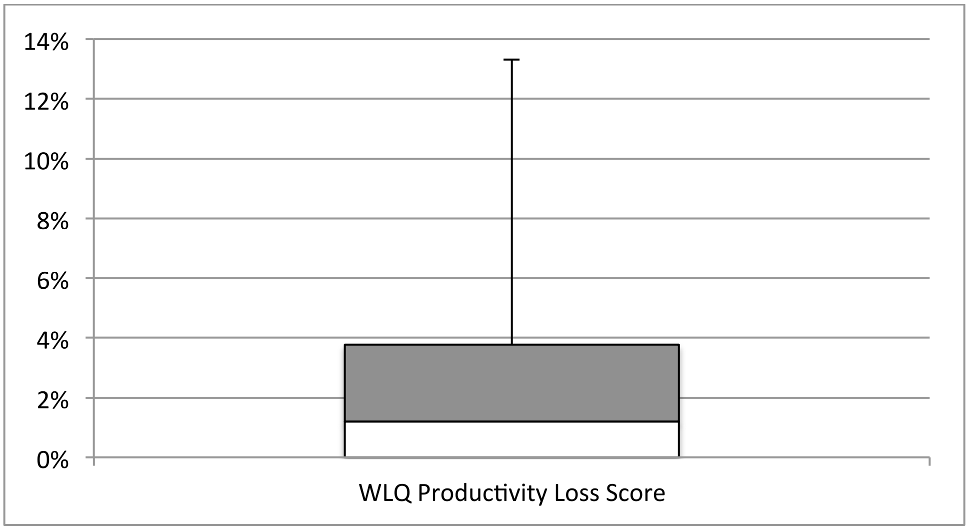

Figure 47: *WLQ Productivity Loss Score (Actigraph Sample)*

Using the dichotomized categories of no impairment and impairment (as WLQ Productivity Loss score of less than 5% and greater than 5%, respectively), 80% (n=33) of respondents were categorized as having no impairment, while 20% (n=8) were categorized as having some impairment.

Table 36
Work Limitations Questionnaire Statistics

	Min/Max	Average (SD)	Median
WLQ Productivity Loss Score	0%/13%	3% (3%)	1%
Time Management Subscale	0/62.5	9.54 (15.5)	0
Physical Subscale	0/75	10.06 (16.82)	0
Mental Interpersonal Subscale	0/50	11.25 (12.27)	12.5
Output Subscale	0/50	7.93 (15.25)	0

6.2.8 Connectivity

Connectivity, a measure of local visibility, varied significantly between spaces. The minimum rating for connectivity was 36.08, and the maximum was 205.83. These are relative measures, based on the floorplan that was analyzed. The average connectivity rating was 89.59 (SD=42.54), and a median of 82.04.

6.2.9 Integration

Integration, a global measure of accessibility, varied significantly between spaces. The minimum rating for integration was 1.97, and the maximum was 5.1. These are relative measures, based on the floorplan that was analyzed. The average integration rating was 3.45 (SD=0.88), and a median of 3.08.

6.2.10 Actigraph Accelerometer

The following statistics were drawn from the ActiGraph measurements. The amount of time the ActiGraph device was worn varied between participants from 1479 to 2671 minutes, with an average wear time of 2089.9 minutes (SD=238.98). Considering the amount of time the device was worn is variable, the following absolute (non-percentage) statistics are not standardized across participants and are dependent on wear time. The statistics showing the percentage of time spent in various activity levels are more accurate representations of sedentary behavior patterns, considering they have been standardized across participants regardless of wear time.

6.2.10.1 Average Length of a Sedentary Bout (Min)

The average bout of sitting observed in the sample was shorter than ten minutes (average=7.34 minutes, SD=2.71 minutes). This means that, on average, individuals spend 7.34 minutes sedentary between breaks in sedentary time. The participant whose average length of sedentary bouts was longest was sedentary for an average of 14.42 minutes at a time, while the participant whose average length of sedentary bouts was shortest was sedentary for an average of only 3.27 minutes at a time.

6.2.10.2 Maximum Length of a Sedentary Bout (Min)

The maximum length of a sedentary bout ranged from 19 minutes to 136 minutes (over two hours), with an average of 59.51 minutes (SD=25.5 minutes). This indicates that the average participant's longest period of uninterrupted sedentary time was roughly one hour.

6.2.10.3 The Average of the Daily Maximum Lengths of Sedentary Time (Min)

The average of the daily maximum lengths of sedentary time represents the average of each participant's maximum lengths of time spent sedentary each day. This value represents the average of the longest times spent sedentary on each of the days that the participant wore the device. The average of the daily maximum lengths of sedentary time ranged from 16.6 minutes to 81.2 minutes, with an average of 40.47 minutes (SD=16.55).

6.2.10.4 Average Amount of Time Spent Sedentary (Min)

The average amount of time each participant spent sedentary per day varied significantly, with the average amount of time spent sedentary per day ranging from 137 minutes to 407 minutes

(2.28 to 6.78 hours). The sample average of the average amount of time spent sedentary per day was 308.17 minutes (SD=58.57) or 5.11 hours.

6.2.10.5 Breaks in Sedentary Time

On average participants took 223.17 breaks between sedentary periods, with a minimum of 135 breaks and a maximum of 344 breaks.

6.2.10.6 Steps

Participants walked an average of 8,460.56 steps (SD=3973.39) over the five-day wear period.

Table 37
Objectively Measured Sedentary Behavior Variables

	Min/Max	Average (SD)	Median
Average Length of a Sedentary Bout (Sec)	196/865	440.63 (162.68)	411
Average Length of a Sedentary Bout (Min)	3.27/14.42	7.34 (2.71)	6.85
Max Length of a Sedentary Bouts (Min)	19/136	59.51 (25.5)	51
Average of the Daily Maximum Lengths of Sedentary Bouts (Min)	16.6/81.2	40.74 (16.55)	37.5
Average Time Spent Sedentary per Day (Min)	137/407	308.17 (58.57)	314
Total Sedentary Breaks	135/344	223.17 (58.01)	214
Step Count	3069/20424	8,460.56 (3,973.39)	7244
Time Worn(Min)	1479/2671	2,089.90 (238.98)	2085

6.2.10.7 Percent of Time Spent in Various Levels of Physical Activity

The percent of time spent in various levels of physical activity are shown below in Table 38. On average, 72.44% (SD=9.98) of time was spent sedentary, 25.47% (SD=8.89)was spent in light physical activity, 2.02% (SD=1.45)was spent in moderate physical activity, and 0.04% (SD=0.09) was spent in vigorous physical activity.

The individual who was sedentary for the largest percentage of their workday was sedentary 87.3% of the time, while the individual who was sedentary for the least percentage of the day was sedentary for only 42.9% of the time.

Only 24% of participants (n=10) engaged in any vigorous physical activity throughout the duration of the study, and the maximum percent of time spent in vigorous physical activity was 0.4%.

Table 38
Objectively Measured Percent of Time Spent in Various Levels of Activity

	Min/Max	Average (SD)	Median
Total % of time Spent in:			
Sedentary behaviors	42.9/87.3	72.44 (9.98)	75
Light physical activity	11.2/51.4	25.47 (8.89)	23.7
Moderate physical activity	0.2/5.6	2.02 (1.45)	1.7
Vigorous physical activity	0/0.4	0.04 (0.09)	0

6.3 ANOVA Analysis

6.3.1 Connectivity

6.3.1.1 Connectivity and Floor

Univariate Analysis of Variance was used to examine the difference in connectivity levels between floors/suites. ANOVA results indicated that average connectivity counts differed significantly across floors/suites (F (7,49) = 3.052, p=.01). Test of Between-Subjects Effects indicated significant effect of floor on connectivity, with an effect size of 0.304 (F=3.052, p=.01, partial eta squared = .304)

Post hoc tests indicate that there were no significant differences between any two individual floors. The means and standard deviations for each floor are provided in Table 39, below.

Table 39
Connectivity Values by Floor

	n	Mean (SD)
Building 1, Floor B	8	120.8 (37.89)
Building 1, Floor 1	11	68.87 (46.21)
Building 1, Floor 2	8	74.41 (24.88)
Building 1, Floor3	2	137.49 (96.65)
Building 1, Floor 4	10	68.85 (27.92)
Building 1, Floor 5	2	133.26 (96.77)
Building 2, Suite 1	12	96.42 (29.72)
Building 2, Suite 2	4	57.14 (14.61)
Total	57	86.58 (42.91)

However, considering significant heterogeneity was observed in the sample (Levine Statistic=2.938, p=.012) robust tests of equality of means were conducted using Welch and Brown-Forsythe statistics. Neither the Welch (p=.112) nor the Brown-Forsythe statistic (p=.428) indicated significant differences between floors.

6.3.1.2 Connectivity and Space Type

Univariate Analysis of Variance was used to examine the difference in connectivity levels between space types, including individual office, cubicles, and reception workplaces. ANOVA results indicated that average connectivity counts differed significantly between space types ($F_{(2,52)} = 11.323$, $p<.001$). Test of Between-Subjects Effects indicated significant effect of space type on connectivity, with an effect size of 0.303 (F=11.323, p<.001, partial eta squared = .303)

Post hoc tests indicate that there were significant differences between the connectivity rating of reception workspaces and both individual offices (mean difference=56.68, p=.003) and cubicles (mean difference=69.75, p<.001). No significant differences were found between the connectivity levels of individual offices and cubicles. The results from the post-hoc analysis of the influence of space type on connectivity indicates that individuals who work in individual offices or cubicles have significantly lower connectivity ratings than those who work in reception workstations.

The means and standard deviations for each space type are provided in Table 40, below.

Table 40
Connectivity Values by Space Type

	n	Mean (SD)
Individual Office	15	86.34 (52.96)
Cubicle	32	73.27 (23.19)
Reception	8	143.02 (47.18)
Total	55	86.98 (43.6)

However, considering significant heterogeneity was observed in the sample (Levine Statistic=12.167, p<.001) robust tests of equality of means were conducted using Welch and Brown-Forsythe statistics. Both the Welch statistic (p=.005) and the Brown-Forsythe statistic (p=.003) remained significant.

6.3.2 Integration

6.3.2.1 Integration and Floor

Univariate Analysis of Variance was used to examine the difference in integration levels between floors. ANOVA results indicated that average integration differed significantly across floors (F (7,49) = 11.075, p<.001). Test of Between-Subjects Effects indicated significant effect of floor on integration, with an effect size of 0.613 (F=11.075, p<.001, partial eta squared = .613)

Post hoc tests indicate that the fifth floor of building 1 and suite 1 of building 2 had significantly lower integration scores than several other floors/suites. The workspaces on the fifth floor of building 1 had significantly lower integration ratings than the workspaces on any of the other floors in building 1. The workspaces in suite 1 of building 2 had significantly lower integration ratings than the workspaces on floors B-4 (basement, and then floors 1-4) of building 1. These differences are shown in Table 41, below.

Table 41
Tukey HSD: Between-Floors Comparison of Integration Ratings

(I) FLOOR	(J) FLOOR	Mean Difference (I-J)	Std. Error	Sig.
Building 1, Floor 5				
	Building 1, Floor B	1.64*	0.43	0.009
	Building 1, Floor 1	1.73*	0.42	0.003
	Building 1, Floor 2	1.78*	0.43	0.003
	Building 1, Floor3	1.97*	0.54	0.015
	Building 1, Floor 4	1.38*	0.42	0.038
	Building 2, Suite 1	0.22	0.42	0.999
	Building 2, Suite 2	1.14	0.47	0.254
Building 2, Suite 1				
	Building 1, Floor B	1.42*	0.25	0.000
	Building 1, Floor 1	1.50*	0.23	0.000
	Building 1, Floor 2	1.55*	0.25	0.000
	Building 1, Floor3	1.75*	0.42	0.003
	Building 1, Floor 4	1.16*	0.23	0.000
	Building 1, Floor 5	0.22	0.42	0.999
	Building 2, Suite 2	0.92	0.31	0.09

* Significant at p < 0.05 (two-tailed)

The integration means and standard deviations for each floor are provided in Table 42, below.

Table 42
Integration Values by Floor

	n	Mean(SD)
Building 1, Floor B	8	2.97 (0.42)
Building 1, Floor 1	11	2.89 (0.41)
Building 1, Floor 2	8	2.84 (0.62)
Building 1, Floor3	2	2.64 (0.28)
Building 1, Floor 4	10	3.23 (0.46)
Building 1, Floor 5	2	4.61 (0.54)
Building 2, Suite 1	12	4.39 (0.62)
Building 2, Suite 2	4	3.47 (0.89)
Total	57	3.36 (0.82)

6.3.2.2 Integration and Space Type

Univariate Analysis of Variance was used to examine the difference in integration levels between space types. ANOVA results indicated that average integration counts differed significantly between space types (F (2,52) = 5.429, p=.007). Test of Between-Subjects Effects indicated significant effect of space type on integration, with an effect size of 0.173 (F=5.429, p=.007, partial eta squared = .173)

Post hoc tests indicate that there were significant differences between the integration ratings of individual offices and cubicles (mean difference=.703, p=.013). No significant differences were found between the integration levels of reception workspaces and either individual offices or cubicles. The results from the post-hoc analysis of the influence of space type on integration indicate that individuals who work in individual offices have significantly lower integration ratings than those who work in cubicles.

The integration means and standard deviations for each space type are provided in Table 43, below.

Table 43
Integration Values by Space Type

	n	Mean (SD)
Individual Office	15	2.97 (0.4)
Cubicle	32	3.67 (0.9)
Reception	8	3.02 (0.61)
Total	55	3.39 (0.82)

However, considering significant heterogeneity was observed in the sample (Levine Statistic=8.710, p=.001) robust tests of equality of means were conducted using Welch and Brown-Forsythe statistics. Both the Welch statistic (p=.006) and the Brown-Forsythe statistic (p=.001) remained significant.

6.3.3 Percent of Time Spent Sedentary

The percent of time spent sedentary varied significantly between spaces. Individuals on different floors, as well as in different office types, spent different amounts of time sedentary.

6.3.3.1 Percent of Time Spent Sedentary and Floor/Suite

ANOVA results indicated that average percent of time spent sedentary differed significantly across floors (F (6,32) = 3.235, p=.013). Test of Between-Subjects Effects indicated significant effect of floor on percent of time spent sedentary, with an effect size of 0.378 (F=3.235, p=.013, partial eta squared = .378)

Post hoc tests indicate that the individuals on the basement floor of building 1 spent significantly different amounts of time in sedentary behaviors than those on other floors 2 and 4 of building 1. These differences are shown in Table 44, below.

Table 44
Tukey HSD: Between-Floors Comparison of Percent Time Spent Sedentary

(I) FLOOR	(J) FLOOR	Mean Difference (I-J)	Std. Error	Sig.
Building 1, Floor B				
	Building 1, Floor 1	11.90	5.27	0.30
	Building 1, Floor 2	-18.217*	5.62	0.04
	Building 1, Floor3	2.57	7.11	1.00
	Building 1, Floor 4	-17.229*	4.70	0.01
	Building 2, Suite 1	12.48	4.35	0.09
	Building 2, Suite 2	17.27	7.11	0.22

* Significant at $p < 0.05$ (two-tailed)

The means and standard deviations of percent of time spent sedentary for each floor are provided in Table 45, below.

Table 45
Percent of Time Spent Sedentary by Floor

	n	Mean (SD)
Building 1, Floor B	6	60.68 (13.56)
Building 1, Floor 1	5	72.58 (4.22)
Building 1, Floor 2	4	78.9 (5)
Building 1, Floor3	2	63.25 (11.67)
Building 1, Floor 4	8	77.91 (6.77)
Building 2, Suite 1	12	73.17 (9.07)
Building 2, Suite 2	2	77.95 (1.63)
Total	39	72.47 (10.13)

However, considering significant heterogeneity was observed in the sample (Levine Statistic=2.948, p=.021) robust tests of equality of means were conducted using Welch and

Brown-Forsythe statistics. Neither the Brown-Forsythe statistic (p=.053) nor the Welch statistic (p=.145) remained significant.

6.3.3.2 Percent of Time Spent Sedentary and Space Type

ANOVA results indicated that average percent of time spent sedentary was not significantly different in different space types. Test of Between-Subjects Effects indicated a non-significant effect of space type on percent of time spent sedentary of 0.139 (F=2.909, p=.067, partial eta squared = .139).

However, considering significant heterogeneity was observed in the sample (Levine Statistic=5.470, p=.008) robust tests of equality of means were conducted using Welch and Brown-Forsythe statistics. Neither the Welch statistic (p=.239) nor the Brown-Forsythe statistic (p=.211) was significant.

The means and standard deviations for each space type are provided in Table 46, below.

Table 46
Percent of Time Spent Sedentary by Space Type

	n	Mean (SD)
Individual Office	12	72.21 (13.25)
Cubicle	22	74.92 (5.73)
Reception	5	63.34 (13.93)
Total	39	72.6 (10.19)

6.4 CORRELATIONAL ANALYSIS

6.4.1 Hypothesis 1: Distance from Amenity Spaces

H.1. Office workers have less sedentary behaviors when their workstations are located relatively closer to shared service and amenity spaces than those whose workstations are located further away from those spaces.

6.4.1.1 Correlation Between Distances

There is a high level of correlation between objective distance measures to different amenity spaces. Objective distance to the restroom is correlated with objective distance to meeting room (r=.345, p=.039) and distance to coffee/break area (r=.403, p=.020). Objective distance to coffee/break area is correlated with distance to meeting room (r=.489, p=.025) and distance to printer (r=.406, p=.023).

Table 47
Pearson Correlation Between Objective Distances

	Obj_Dist_ Bathroom	Obj_Dist_ Meeting Room	Obj_Dist_ Printer
Obj_Dist_Bathroom	1		
Obj_Dist_MeetingRoom	0.345*	1	
Obj_Dist_Printer	0.023	0.005	1
Obj_Dist_Coffee	0.403*	0.489*	0.406*

* Significant at p < 0.05 (two-tailed).

6.4.1.2 Objective Vs. Self-Report Distance Measures

On the whole, self-report and objective measures of distances to various amenity spaces correlated only slightly. There was no significant correlation between objective and self-reported distance to meeting rooms (r=.202, p=.302) or objective and self-report distance to coffee/break area (r=.140, p=.468). The correlation between objective and self-report distance to printer/copy area was r=.675, and this relationship did reach significance (p<.001), as did the correlation between objective and self-report distance to restrooms (r=.425, p=.002).

This suggests that self-reported distances are unreliable estimates of distances to meeting rooms and coffee/break areas, but that self-reported distance to restrooms and printer/copy areas are relatively accurate.

Objectively measured distances to each individual amenity space were tested separately for correlation with accelerometer-derived percent sedentary time, percent light PA, percent moderate PA, and percent vigorous PA. The average of distance measures for each workspace was also included (the average of distance to bathroom, meeting room, printer/copier, and coffee/break area for each workspace) when two or more distance measures were available. For workstations where a measure was not available, the average of the available measures were taken (for example if one individual did not have a measure for 'Distance to meeting room" their remaining three distances would be averaged together). Where only one measure was present, this was excluded from the average analysis.

Self-reported measures of distance to each amenity space were also tested against accelerometer-derived percent sedentary time, percent light PA, percent moderate PA, and percent vigorous PA, keeping in mind that these may not represent the most accurate physical distances but may reflect cognitive distances/user perceptions of distances to these spaces, which can also influence behavior.

6.4.1.3 Average Length of Sedentary Bout

Objective: The average length of a sedentary bout was not significantly correlated with any of the objective distance measures.

Self-Report: The average length of a sedentary bout was correlated with only one self-report distance measure, and that is the distance to coffee/break area (r=-.404, p=.013). The correlation between average length of sedentary bout and self-reported distance from printing/copier approached significance (r=-.303, p=.061). This finding suggests that individuals who report that their workstations are relatively further from coffee/break areas will tend to have shorter periods of sedentary behavior than those who report that their workstations are relatively closer.

Table 48
Pearson Correlation Between Average Length of Sedentary Bout and Self-Report Distance Measures

	SR_Dist_Coffee	SR_Dist_Printing
Ave_Legth_ Sed_Bout_Sec	-0.404*	-0.303 (p=0.061)

* Significant at p < 0.05 (two-tailed)

6.4.1.4 Maximum Length of a Sedentary Bout

Objective: The maximum length of a sedentary bout was not significantly correlated with any of the objective distance measures.

Self-Report: The maximum length of a sedentary bout was not significantly correlated with any of the self-reported distance measures.

6.4.1.5 Average of the Daily Maximum Length of a Sedentary Bout

The maximum lengths of a sedentary bout for each of the (up to five) sample days were averaged to produce this variable.

Objective: The average of the daily maximum length of a sedentary bout was not significantly correlated with any of the objective distance measures.

Self-Report: *The average of the daily maximum length of a sedentary bout was significantly correlated with self-reported distance from coffee/break area ($r=-.407$, $p=.012$). This finding suggests that the length of the longest sitting period is greater for individuals who report that their workstations are relatively closer to coffee/break areas.*

6.4.1.6 Daily Average Sedentary Bouts (Average amount of time spent in sedentary bouts per day)

Objective: The daily average sedentary bouts were correlated with only one objective distance measure, distance from the printer/copier (r=-.519, p=.013). This finding suggests that individuals whose workstations are relatively further from printer/copier areas will tend to spend less time engaged in sedentary behaviors, on average, than those who report that their workstations are relatively closer.

Self-Report: The daily average sedentary bouts were correlated with two self-reported distance measures, distance to mail room (r=-.396, p=.034) and distance from coffee/break area (r=-.524, p=.001). This finding suggests that individuals who report that their workstations are relatively further from coffee/break areas and mail rooms will tend to have shorter periods of sedentary behavior than those who report that their workstations are relatively closer to these spaces.

Table 49
Pearson Correlation Between Average Number of Minutes Spent Sedentary/Day and Self-Report Distance Measures

	SR_Dist_Mail	SR_Dist_Coffee
Daily_Ave_Sed_Bout_Min	-.396*	-.524**

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

6.4.1.7 Total Number of Sedentary Breaks (Breaks in Sedentary Time)

Objective: There were no significant correlations between the total number of sedentary breaks and any objective distance measures.

Self-report: The total number of sedentary breaks was correlated with self-reported distance from printer/copier (r=.342, p=.036). This finding suggests that individuals who report that their workstations are relatively further from printer/copier areas will tend to have more breaks between sedentary periods than those whose workstations are relatively closer.

6.4.1.8 Percent of Time Spent Sedentary

Objective: There were no significant correlations between percent of time spent in sedentary behaviors and any objective distance measures.

Self-Report: There were significant correlations between percent of time spent sedentary and self-reported distance from printer/copier (r=-.399, p=.013) and coffee/break area (r=-.572, p=<0.001). This finding suggests that individuals who report that their workstations are relatively further from printer/copier and coffee/break areas will tend to spend a smaller percentage of their time engaged in sedentary behaviors than those who report that their workstations are relatively closer.

Table 50
Pearson Correlation Between Percent of Time Spent Sedentary and Self-Report Distance Measures

	SR_Dist_Printing	SR_Dist_Coffee
Percent_Sedentary	-.399*	-.572**

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

6.4.1.9 Percent of Time Spent in Light Physical Activity

Objective: There were no significant correlations between percent of time spent in light physical activity and any objective distance measures.

Self-report: There were significant correlations between percent of time spent in light physical activity and self-reported distance from printer/copier (r=.403, p=.012) and coffee/break area (r=-.570, p<.001). This finding suggests that individuals who report that their workstations are relatively further from printer/copier and coffee/break areas will tend to spend a greater percentage of their time engaged in light physical activity than those who report that their workstations are relatively closer.

Table 51
Pearson Correlation Between Percent of Time Spent in Light Physical Activity and Self-Report Distance Measures

	SR_Dist_Printing	SR_Dist_Coffee
Percent_Light Physical Activity	.403*	.570**

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

6.4.1.10 Percent of Time Spent in Moderate Physical Activity

Objective: There were significant correlations between the percent of time spent in moderate physical activity and objectively measured distance from the restroom (r=.389, p=.012), distance from printer/copier (r=.690, p<.001), and distance from coffee/break area (r=.459, p=.036). This finding suggests that individuals whose workstations are relatively further from restrooms, printer/copier areas, and coffee/break areas will tend to spend a greater percentage of their time engaged in moderate physical activity than those who report that their workstations are relatively closer.

Self-report: There were significant correlations between the percent of time spent in moderate physical activity and self-reported distance from the mail room (r=.444, p=.018) and distance from coffee/break room (r=.454, p=.005). This finding suggests that individuals who report that their workstations are relatively further from mail rooms and coffee/break areas will tend to spend a greater percentage of their time engaged in moderate physical activity than those who report that their workstations are relatively closer.

Table 52
Pearson Correlation Between Percent of Time Spent in Moderate Physical Activity and Distance Measures (Objective and Self-Report)

	Obj_Dist_ Bathroom	Obj_Dist _Printer	Obj_Dist_ Coffee	SR_Dist_C offee	SR_Dist_ Mail
Percent_ Moderate	.389*	.690**	.459*	.454**	.444*

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

6.4.1.11 Percent of Time Spent in Vigorous Physical Activity

There were no significant correlations between percent of time spent in vigorous physical activity and either objectively measured or self-reported distance from amenity spaces.

6.4.1.12 Step Count

Objective: There was a significant correlation between total step count and objectively measured distance from printer/copier (r=.585, p=.004).The correlation between total step count and objectively measured distance from coffee/break area approached significance (r=.423, p=.056)

Self-Report: There was a significant correlation between total step count and self-reported distance from coffee/break area (r=.369, p=.024).

Table 53
Pearson Correlation Between Step Count and Distance Measures (Objective and Self-Report)

	Obj_Dist_Printer	Obj_Dist_Coffee	SR_Dist_Coffee
Step_Count	.585**	0.423 (p=0.056)	.369*

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

6.4.1.13 Hypothesis 1 Conclusion

Hypothesis 1 was not supported by the findings of this study, and instead an inverse relationship was found. The trends indicate that individual whose workstations are closer to amenity spaces (and in particular coffee/break areas) spend a greater percent of time sedentary and less in light and moderate physical activity, take less steps per day, and have longer lengths of individual sedentary periods. So individuals whose workstations are further away from amenity spaces tend to engage in less sedentary behavior.

6.4.2 Hypothesis 2: Connectivity

H.2. Office workers have more sedentary behaviors when their workstations have low visibility, measured by the space syntax variable "Connectivity," than those whose workstations have high visibility.

Connectivity: This term refers to the number of spaces to which a particular space is directly visually linked; or the number of spaces that are being seen (are being controlled) by this particular space; it is measured simply by counting the number of links for each point. The higher the connectivity of a point is, the greater are its chances of use (Raford & Ragland, 2003) and encounter (From Zadeh, Shepley Wagoner, 2012).

6.4.2.1 Average Length of Sedentary Bout

There was no significant relationship between average length of sedentary bout and workstation connectivity, however the correlation approached significance ($r=-.276$, $p=.081$).

6.4.2.2 Maximum Length of a Sedentary Bout

There was no significant relationship between the maximum length of a sedentary bout and workstation connectivity

6.4.2.3 Average of the Daily Maximum Length of a Sedentary Bout

There was a significant correlation between the average of the daily maximum length of a sedentary bout and connectivity ($r=-.330$, $p=.038$). This finding suggests that as the visibility of a workstation increases, the length of the longest sitting period of the individual in that workstation tends to decrease. In other words, individuals working in workstations with low visibility will tend to sit for longer periods of time than those who work in workstations with high visibility.

6.4.2.4 Daily Average Sedentary Bouts (Average amount of time spent in sedentary bouts per day)

There was a significant correlation between the average amount of time spent in sedentary bouts per day and connectivity (r=-.431, p=.005). This result suggests that individuals who work in workstations with high visibility will tend to have more breaks between periods of sedentary behavior than those whose workstations have low visibility.

6.4.2.5 Total Number of Sedentary Breaks (Breaks in Sedentary Time)

There was no significant relationship between the total number of sedentary breaks and workstation connectivity.

6.4.2.6 Percent of Time Spent Sedentary

There was a significant correlation between the percent of time spent sedentary and connectivity (r=-.512, p=.001).

6.4.2.7 Percent of Time Spent in Light Physical Activity

There was a significant correlation between the percent of time spent in light physical activity and connectivity (r=.511, p=.001). This finding suggests that individuals who work in workstations with high visibility will tend to spend a larger percent of time in light physical activities than those whose workstations have less visibility.

6.4.2.8 Percent of Time Spent in Moderate Physical Activity

There was a significant correlation between the percent of time spent in moderate physical activity and connectivity (r=.399, p=.011). This finding suggests that individuals who work in workstations with high visibility will tend to spend a larger percent of time in moderate physical activities than those whose workstations have less visibility.

6.4.2.9 Percent of Time Spent in Vigorous Physical Activity

There was no significant relationship between the percent of time spent in vigorous physical activity and workstation connectivity.

6.4.2.10 Step Count

There was a significant correlation between total step count and connectivity (r=.495, p=.001). This finding suggests that individuals who work in workstations that have high visibility will tend to take more steps during the workday than those whose workstations have less visibility.

Summary of Significant Findings:

Table 54
Pearson Correlations Between Connectivity and Measures of Sedentary Behavior and Physical Activity

	Connectivity (Visibility)
Daily_Ave_Sed_Bout_Min	-0.431**
Percent_Sedentary	-0.512**
Percent_Light	0.511**
Percent_Moderate	0.399*
Ave_Daily_Max_Sed_Bout_Min	-0.330*
Step_Count	0.495**

* Significant at $p < 0.05$ (two-tailed)
** Significant at $p < 0.01$ (two-tailed)

6.4.2.11 Hypothesis 2 Conclusion

Hypothesis 2 was supported by the findings of this study. Individuals whose workspaces rated high on connectivity, a measure of the visibility of a space, were shown to spend less time in sedentary behaviors per day, spend a smaller percent of time engaged in sedentary behaviors, spend a greater percent of time in light and moderate physical activity, engage in shorter periods of sedentary behavior, and take more steps.

The results suggest that when a workspace has high visibility, or is can be seen from many other spaces in the office, the individual in that workspace will engage in less sedentary behavior. So individuals whose workspaces have low connectivity engage in more sedentary behaviors.

6.4.3 Hypothesis 3: Integration

H.3. Office workers have more sedentary behaviors when their workstations have low overall integration compared to those whose workstations have high overall connectivity.

A global measure: The integration of a space is the measure of its relationship to all other points in the system (Hanson, 1998; Marcus & Cameron, 2002). Integration can be calculated by a computer program that measures the chance of foot traffic and encounters for one space on a system scale. The higher the integration value is, the busier the space; a lower value indicates a more segregated space (Hanson, 1998; Mills & Zadeh, 2009; Raford & Ragland, 2003) and a higher "movement potential" (Raford & Ragland, 2003). (From Zadeh, Shepley Wagoner, 2012)

Highly integrated areas are those where we usually run into a friend accidentally and have impromptu conversations (ease of access to all other locations and chance of and chance of encounter by others from a global perspective)

The default measure displayed is the 'integration' of every location, a measure of how deep each location is to all others. A well integrated location (colored in red) is shallow, that is you do not have to turn often to get from that location to any other location in the system. Conversely, a poor integrated location (colored in dark blue) is deep with respect to the other locations

Integration was not significantly correlated to any measures of sedentary time, including Average Length of Sedentary Bout, Maximum Length of a Sedentary Bout, Average of the Daily Maximum Length of a Sedentary Bout, Daily Average Sedentary Bouts (Average amount of time spent in sedentary bouts per day), Total Number of Sedentary Breaks (Breaks in Sedentary Time), Percent of Time Spent Sedentary, Percent of Time Spent in Light Physical Activity, Percent of Time Spent in Moderate Physical Activity, Percent of Time Spent in Vigorous Physical Activity, Step Count.

6.4.3.1 Hypothesis 3 Conclusion

Hypothesis 3 was not supported by the findings of this study.

6.4.4 Hypothesis 4: Presenteeism

H.4. Employee presenteeism (level of impairment as measured by the WLQ) will be positively associated with occupational sedentary behavior.

Only one significant correlation was found between the WLQ Productivity Loss Score and activity patterns, and that is the relationship between WLQ Productivity Loss Score and percent of time spent in vigorous physical activity (r=.361, p=.024). Significant correlations were also found between percent of time spent in vigorous physical activity and two of the WLQ subscales, including Time Management subscale (r=.403, p=.011) and the Mental/Interpersonal subscale (r=.468, p=.003).

Table 55
Pearson Correlations Between Percent of Time Spent in Vigorous Physical Activity and the WLQ

	WLQ_Productivity_Loss_Score	Time_Management Subscale	Mental_Interpersonal Subscale
Percent_Vigorous	.361*	.403*	.468**

* Significant at p < 0.05 (two-tailed)
** Significant at p < 0.01 (two-tailed)

No significant correlations were found between the WLQ Productivity Loss Score or any of the WLQ subscales and Average Length of Sedentary Bout, Maximum Length of a Sedentary Bout, Average of the Daily Maximum Length of a Sedentary Bout, Daily Average Sedentary Bouts (Average amount of time spent in sedentary bouts per day), Total Number of Sedentary Breaks (Breaks in Sedentary Time), Percent of Time Spent Sedentary, Percent of Time Spent in Light Physical Activity, Percent of Time Spent in Moderate Physical Activity, or Step Count.

6.4.4.1 Hypothesis 4 Conclusions

Hypothesis 4 was not supported by the findings of this study.

6.5 Regression Analysis

Two different approaches to regression analysis were utilized.

The first approach used independent univariate regressions to identify the variables that were independently significantly associated with percent of time spent sedentary. These independently significant variables were then combined into a single model.

While there is value in the first method of selecting the significant results from a multiplicity of parallel tests as this can provide insight into individual relationships – because we know factors are never working individually, and are instead constantly interacting with each other to influence behavior, this approach poses the risk of reaching an incorrect conclusion.

The second approach used a stepwise reduction method. All of the variables were put into a regression model jointly, and then non-significant variables were subsequently removed from the model one by one, beginning with the least significant predictors. Regression was performed on the remaining variables after the removal of each variable, until only variables with a significance of less than p=0.05 remained in the model.

6.5.1 Univariate Model Building

6.5.1.1 Integration and Connectivity

Percent of time spent in sedentary behaviors was regressed on both connectivity and integration independently. Regression results indicated that connectivity explained 26.2% of the variance in percent of time spent sedentary (R^2= .262, p=.001). It was found that connectivity significantly predicted sedentary behaviors (B=-0.12, p=.001). Integration was found to have a weak and non-significant relationship to percent sedentary time and so was left out from future models.

6.5.1.2 WLQ

The percent of time spent sedentary was regressed on WLQ Productivity Loss Score, and no relationships were found. Percent of time spent sedentary was regressed on each of the WLQ subscales independently, and similarly no relationships were found. Considering this finding WLQ measures were left out of future models.

6.5.1.3 Distance Variables

Objectively Measured

Percent of time spent sedentary was regressed on each of the objective distance measures independently (distance to restroom, distance to meeting room, distance to printer/copier, and distance to coffee/break area), and no significant relationships were found.

Self-Report

Percent of time spent sedentary was regressed on each of the self-reported distance measures independently. Self-reported distance from a printer/copier was found to explain 15.9% of the variance (R^2=.159, p=.013), and also significantly predicted sedentary behaviors (B=-.206, p=.013). Self-reported distance from coffee/break area was found to explain 32.7% of the variance (R^2=.327, p<.001), and also significantly predicted sedentary behavior (B=-.153, p<.001).

No relationships were found for self-reported distance to meeting room, distance from mail room, or distance from bathroom.

6.5.1.4 Combining Independently Significant Relationships into Model

In a model that regressed percent of time spent sedentary on the three relationships that were found to be independently significant predictors of percent time spent sedentary (connectivity, self-reported distance from printer/copier, and self-reported distance from coffee/break area), connectivity (B=-.086, p=.013) and self-reported distance from coffee/break area (B=-.129, p=.002) remained significant, while self-reported distance from printing was no longer significant. The overall model fit was 51% (R^2=.511).

The two remaining significant relationships (connectivity and self-reported distance from coffee/break area) were then used in the final model, and percent time spent sedentary was regressed onto these two variables. Both variables remained significant, and the predictive power of the model was 49% (R^2=.499). Connectivity was shown to have a B=-.09 (p=.005) and self-reported distance from coffee/break area was shown to have a B=-.136 (p<.001)

Model 1: Connectivity and Self-reported Distance from Coffee/Break Area

Percent of Time Spent Sedentary = 87.1 + (-0.09*Connectivity) + (-0.136*Self-reported Distance from Coffee/Break Area)

Table 56
Model 1 Summary

	Beta	95% CI	Significance
Intercept	87.104	80.736 / 93.471	<.001
Connectivity	-0.09	-0.152 / -0.029	.005
Self-reported Distance from Coffee/Break Area	-.136	-.206 / -.066	<.001

Dependent Variable: Percent of Time Spent Sedentary

6.5.1.5 Univariate Model Building: Adding Demographic Covariates

Demographic variables (gender, age, BMI, race, position) were added to Model 1, and non-significant variables were subsequently removed from the model one by one using a stepwise reduction method, beginning with the least significant predictors. Upon this reduction, the only factors that remained significant predictors of sedentary time were connectivity (p=.001) and position (p=.001). The overall fit of the model was 53%.

Model 2: Connectivity and Position

Percent of Time Spent Sedentary = 82.84 + (-0.107*Connectivity) + (-22.007 if Position=Technician) + (-0.257 if Position=Research Staff) + (6.441 if Position=Management) + (0 if Position=Administration/Support)

Table 57
Model 2 Summary

	Beta	95% CI	Significance
Intercept	82.84	76.896 / 88.779	<.001
Connectivity	-0.107	-0.168 / -0.046	.001
Position			.001
Technician	-22.007	-33.267 / -10.748	<.001
Research Staff	-0.257	-7.559 / 7.046	.943
Management	6.441	-3.058 / 15.94	.177
Administration/Support	0		

Dependent Variable: Percent of Time Spent Sedentary

In another model, only select demographic variables were added to Model 1 (gender, age, BMI), and race and position were left out. This was done because the position of the participants may influence behaviors in ways that are not being controlled for, and so this model gave insight to the effects of other demographic variables without the influence of position. Using this model, connectivity (p=.005) and self-reported distance from coffee/break area (p<.001), and no demographic variables remains significant. This suggests that connectivity and self-reported distance from coffee/break area influence sedentary behavior.

Model 3: Connectivity and Self-reported Distance from Coffee/Break Area

Percent of Time Spent Sedentary = 87.104 + (-0.09*Connectivity) + (-0.136*Self-reported Distance from Coffee/Break Area)

Table 58
Model 3 Summary

	Beta	95% CI	Significance
Intercept	87.104	80.736 / 93.471	<.001
Connectivity	-0.09	-0.152 / -0.029	.005
Self-reported Distance from Coffee/Break Area	-.136	-.206 / -.066	<.001

Dependent Variable: Percent of Time Spent Sedentary

6.5.2 Stepwise Reduction of Full Multivariable Model

All predictive variables were put into a multiple regression analysis jointly, and a stepwise reduction method was run on this model. Objective and self-report distances were included in separate models.

6.5.2.1 Objective Distance Model

A regression analysis was performed which included all objective distance measures (distance from meeting room, restroom, printer, and coffee/break area), integration, connectivity, and WLQ productivity loss score. Non-significant variables were subsequently removed from the model one by one using a stepwise reduction method, beginning with the least significant predictors. Regression was performed on the remaining variables after the removal of each variable, until only variables with a significance at p<0.05 remained in the model. The final model included connectivity (p=.001) and objectively measured distance to meeting room(p=.024). The overall fit of the model was 40%.

Model 4: Connectivity and Objectively Measured Distance from Meeting Room

Percent of Time Spent Sedentary = 80.102 + (-0.194*Connectivity) + (0.117*Objectively Measured Distance from Meeting Room)

Table 59
Model 4 Summary

	Beta	95% CI	Significance
Intercept	80.102	70.17 / 90.03	<.001
Connectivity	-0.194	-0.297 / -0.091	.001
Objective Distance from Meeting Room	0.117	0.017 / 0.218	.024

Dependent Variable: Percent of Time Spent Sedentary

Demographic variables were then introduced into Model 4 (gender, age, BMI, position). Non-significant demographic variables were subsequently removed from the model one by one, beginning with the least significant predictors. Regression was performed on the remaining variables after the removal of each variable, until only variables with a significance of less than $p<.05$ remained in the model. Both connectivity ($p<.001$) and objectively measured distance to meeting room ($p=.003$) remained significant predictors of sedentary time, and position ($p=.001$) was also seen to be a significant predictor. The final model includes objective distance from meeting rooms, connectivity, and position. The model fit was R2=.739.

Model 5: Connectivity, Objective Distance from Meeting Room, and Position

Percent of Time Spent Sedentary = 79.435 + (-0.181*Connectivity) + (0.120*Objective Distance from Meeting Room) + (-22.207 if Position=Technician) + (-0.8 if

Position=Research Staff) + (5.064 if Position=Management) + (0 if Position=Administration/Support)

Table 60
Model 5 Summary

	Beta	95% CI	Significance
Intercept	79.435	71.922 / 86.948	<.001
Connectivity	-0.181	-.259 / -.104	<.001
Objective Distance from Meeting Room	0.120	.045 / .196	.003
Position			.001
Technician	-22.207	-33.544 / -11.87	<.001
Research Staff	-0.8	-10.986 / 9.386	.871
Management	5.064	-3.754 / 13.882	.244
Administration/Support	0		

Dependent Variable: Percent of Time Spent Sedentary

In another model, only select demographic variables were added to Model 4 (gender, age, BMI), and position was left out. This was done because the position of the participants may influence behaviors in ways that are not being controlled for, and so this model gave insight to the effects of other demographic variables without the influence of position. Using this model, connectivity ($p<.001$), objective distance from meeting room ($p=.006$), and gender ($p=.037$) remained significant. This suggests that connectivity and objective distance from meeting room influence sedentary behavior after controlling for gender.

Model 6: Connectivity, Objective Distance from Meeting Room, and Gender

Percent of Time Spent Sedentary = 80.120 + (-0.195*Connectivity) + (0.141*Objectively Measured Distance from Meeting Room) + (-8.520 if Male) + (0 if Female)

Table 61 Model 6 Summary			
	Beta	95% CI	Significance
Intercept	80.120	70.717 / 89.523	<.001
Connectivity	-.195	-.292 / -.099	<.001
Objective Distance from Meeting Room	.141	.045 / .238	.006
Gender			.037
Male	-8.52	-16.489 / -.551	.037
Female	0		

Dependent Variable: Percent of Time Spent Sedentary

6.5.2.2 Self-reported Distance Model

All of the self-report distance variables, connectivity, integration, and the WLQ productivity loss score were included in an original model. Non-significant predictors were then removed from the model one by one, beginning with the least significant, until all remaining variables reached significance. Using this technique, only self-reported distance from coffee/break area remained a significant predictor of sedentary time (p<.001).

Model 7: Self-reported distance from Coffee/Break Area

Percent of Time Spent Sedentary = 79.145 + (-0.153*Self-reported Distance from Coffee/Break Area)

Table 62 Model 7 Summary			
	Beta	95% CI	Significance
Intercept	79.145	74.626 / 83.664	<.001
Self-reported Distance from Coffee/Break Area	-.153	-.228 / -.078	<.001

Dependent Variable: Percent of Time Spent Sedentary

When demographic variables were added to this model, while self-reported distance from coffee/break area remained significant, no demographic variables remained significant. The resulting model was the same as Model 7.

For this reason, a different approach was taken, where all of the self-report distance variables, connectivity, integration, and the WLQ productivity loss score were included in an original model *along with* select demographic variables (gender, age, BMI). Stepwise reduction was then performed on this model. This analysis showed that only connectivity (p=.001) remained a significant predictor of sedentary time in a reduced model. The overall fit of the model was 26%.

Model 8: Connectivity

Percent of Time Spent Sedentary = 83.419 + (-0.120*Connectivity)

Table 63
Model 8 Summary

	Beta	95% CI	Significance
Intercept	83.419	76.835 / 90.002	<.001
Connectivity	-.120	-.186 / -.054	.001

Dependent Variable: Percent of Time Spent Sedentary

CHAPTER 7: DISCUSSION

7.1 Key Results

7.1.1 Key Survey Results

In general, the participants surveyed did not participate in enough physical activity, with 70% reporting that they felt they did not get enough physical activity. Thirty six percent of the participants reported that they got 10 minutes of continuous moderate PA on only 1 or no days per week, and another 23% reported they got 10 minutes of continuous walking on only 1 or no days per week.

7.1.2 Significant Correlations

7.1.2.1 Distance Measures

As distance from workspaces to amenity spaces increased, the amount of time spent in sedentary behaviors decreased, and the amount of time spent in light and moderate physical activity increased. Consistent relationships were found with both self-reported and objectively measured distances, however self-reported distances were more frequently significantly related to sedentary behavior variables than were objectively-measured distances.

Significant relationships indicated that as both self-reported and objectively measured distance from amenity spaces increased:

- The amount of time spent sedentary decreased.
- Step counts increased
- Percent of time spent in moderate physical activity increased

The following variables were only correlated with self-reported distances; as self-reported distance from amenity spaces increased:

- Percent of time spent sedentary decreased
- The number of breaks in sedentary time increased
- The average length of a sedentary period decreased
- The percent of time spent in light physical activity increased

One of the main reasons that significant correlations with percent of time spent sedentary were found with self-reported distances but not with objectively measured distances is due to sample size. Fewer workstations (sample size 21~26) were able to be objectively analyzed on all four distance measures due to ambiguity in destination (for example if several meeting spaces are frequently used), while a larger proportion of participants self-reported their distance measures (sample size ~37).

The positive relationship observed between time spent in moderate physical activity and both objective and self-reported distance measures (objective restroom, printer/copier, and coffee/break area; self-report mail room and coffee/break room) suggests that the amount of time spent in moderate physical activity is strongly related to spatial distances. Individuals whose workstations are relatively further from these amenity spaces engage in significantly more moderate physical activity than those whose workspaces are relatively closer to these spaces. Both self-reported and objectively measured distance from the coffee/break room were correlated with percent of time spent in moderate physical activity, suggesting that this is an important factor in relation to moderate physical activity.

The lack of correlation between vigorous physical activity and any distance measures is not surprising, given the nature of the work and the sampling procedures employed (accelerometer only worn during work hours, while inside the building of study). Only 24% of participants (n=10) recorded any vigorous time at all, and even these were negligibly small amounts (~0.1%). This small sample size of individuals who engaged in vigorous physical activity may have limited the power of the statistical analysis.

Overall, these findings suggest that individuals will engage in more sedentary behaviors when their workstations are located closer to amenity spaces than when their workstations are located relatively further from these spaces.

The key variables that the correlational analysis found to be significantly related to sedentary behavior include distance from coffee/break area and distance from printer/copier. Both the self-report and objectively measured distances to these two spaces were significantly correlated with sedentary time.

Two distance measures were only significant to either objectively measured or self-reported measures, but not both, and these were self-report distance from mail room and objective distance from restroom.

All significant findings can be seen in Table 64, below.

7.1.2.2 Connectivity

Connectivity was significantly related to several measures of sedentary time. The general trends indicate that as connectivity increases, the amount of time spent in sedentary behaviors decreases, and the amount of time spent in light and moderate physical activities increases.

The negative relationship between various sedentary behavior variables and connectivity suggest that individuals will engage in less sedentary behaviors when their workstations are highly visible (high connectivity) than when their workstations are less visible (low connectivity). Individuals spend a greater percent of their time sedentary when their workstations have low connectivity.

The positive relationship between connectivity and both percent time spent in light physical activity and percent of time spent in moderate physical activity suggest that individuals whose workspaces are highly visible (high connectivity) will engage in more light and moderate physical activity than those whose workstations have low visibility (low connectivity). The percent of time engaged in light or moderate physical activity is higher when a workstation has high connectivity.

Significant findings can be seen in Table 64, below.

Table 64
Sedentary Behavior Variables Associated with Distance Measures and Connectivity

	Variables Significantly Associated at p<.05
Self-reported distance from coffee/break area	percent of time spent sedentary (-), average length of a sedentary period (-), amount of time spent in sedentary behavior per day (-) step count (+) and time spent in light and moderate physical activity (+)
Self-reported distance from printer/copier	percent of time spent sedentary (-) breaks in sedentary time (+) and percent of time spent in light physical activity (+)

Self-reported distance from mail room	average amount of time spent sedentary (-) and percent of time spent in moderate physical activity (+)
Objectively measured distance from printer/copier	amount of time spent sedentary (-), step count (+) and percent time spent in moderate physical activity (+)
Objectively measured distance from restroom	percent time spent in moderate physical activity (+)
Objectively measured distance from coffee/break area	percent time spent in moderate physical activity (+)
Connectivity	amount of time spent in sedentary behavior per day (-), percent of time spent sedentary (-), percent of time spent in light (+) and moderate (+) physical activity, maximum length of a sedentary period (-) and step count (+)

7.1.2.3 Integration

No significant relationships were found with Integration and any sedentary behavior variables.

7.1.2.4 WLQ

The only finding regarding the WLQ Productivity Loss Score was a positive association with the percent of time spent in vigorous physical activity. This suggests that individuals who have a higher WLQ Productivity Loss Score (i.e. are more impaired at work) also engage in more vigorous physical activity at work. Conversely, individuals who engage in more vigorous physical activity at work tend to be more impaired at work (higher WLQ Productivity Loss Score).

7.1.3 Regression Models

Two approaches to regression were taken: the building of a multivariable model from multiple univariate analyses, and the stepwise reduction of a fully adjusted model.

Both approaches reached the same conclusions regarding connectivity and self-reported distance from coffee/break area.

The final model that resulted from the univariate to multivariable model building process included connectivity and self-reported distance from coffee/break area. Upon the addition of demographic variables into the model, both connectivity and self-reported distance from coffee/break area were shown to significantly predict sedentary time (Model 3). This finding suggests that connectivity and self-reported distance from coffee/break area remain significant predictors of sedentary time in office workers.

Using the stepwise reduction approach, the resulting model for self-reported distances included self-reported distance from coffee/break area (Model 7). Upon the addition of demographic variables the same results were found.

Using the stepwise reduction approach, the resulting model for objective distances included connectivity, objectively measured distance from meeting room, and position. Together these three variables were shown to account for 73% of the variance in percent of time spent sedentary.

This result suggests that the connectivity of individual workspaces has a significant impact on the percent of time spent in sedentary behaviors, in accordance with Hypothesis 2, as it was present in each of the regression models. These results indicate that, as the connectivity of a workspace increases, the percent of time spent sedentary by the occupant of that workspace will decrease. Similarly, self-reported distance from coffee/break areas was found to be an important factor, as it remained in the models reached by both the univariate to multivariable model building as well as the stepwise reduction method. The results suggest that as self-reported distance from coffee/break areas increase, the amount of time spent sedentary will decrease.

The demographic variables that remained significantly related to sedentary time in the various regression models were position and gender. These findings regarding the demographic variables were not surprising to this author. The daily tasks associated with different job roles can have significant influence on the activity patterns of employees. Controlling for this variability in job roles, however, connectivity and distance from meeting spaces remained significant predictors of sedentary time, suggesting that regardless of the position of the employee connectivity and distance from meeting spaces are important physical environment variables that impact the sedentary behavior patterns of office workers.

7.2 Hypothesis Discussion

7.2.1 Hypothesis 1: Distance Measures

The results of this study do not support Hypothesis 1 that office workers have less sedentary behaviors when their workstations are located relatively closer to shared service and amenity spaces. On the contrary, these findings suggest an opposite conclusion – that office workers have less sedentary time when their workstations are located relatively further away from shared service and amenity spaces. This relationship is shown in Tables 65 and 66, with negative correlation coefficients indicating this inverse relationship between both objective and self-report distances from amenity spaces and various sedentary behaviors.

Table 65
Pearson Correlations Between Sedentary Behavior Variables and Objectively Measured Distance Measures

	Obj. Distance to Restroom	Obj. Distance to Meeting Room	Obj. Distance to Printer	Obj. Distance to Coffee
Ave_Legth_Sed_Bout_Sec	--	--	--	--
Max_Length_Sed_Bout_Min	--	--	--	--
Daily_Ave_Sed_Bout_Min	--	--	-.519*	--
Toal_Sed_Breaks	--	--		--
Percent_Sedentary	--	--		--
Percent_Light	--	--		--
Percent_Moderate	.389*	--	.690**	.459*
Percent_Vigorous	--	--	--	--
Ave_Daily_Max_Sed_Bout_Min	--	--	--	--
Step_Count	--	--	.585**	--

* Significant at $p < 0.05$ (two-tailed)
** Significant at $p < 0.01$ (two-tailed)

Table 66
Pearson Correlations Between Sedentary Behavior Variables and Self-Reported Distance Measures

	Self-Report Distance to Meeting Room	Self-Report Distance to Printer	Self-Report Distance to Mail Room	Self-Report Distance to Coffee/Break Area	Self-Report Distance to Restroom
Ave_Legth_Sed_Bout_Sec	--	--	--	-.404*	--
Max_Length_Sed_Bout_Min	--	--	--	-0.23	--
Daily_Ave_Sed_Bout_Min	--	--	-.396*	-.524**	--
Toal_Sed_Breaks	--	.342*	--		--

Percent_Sedentary	--	-.399*	--	-.572**	--
Percent_Light	--	.403*	--	.570**	--
Percent_Moderate	--	--	.444*	.454**	--
Percent_Vigorous	--	--	--	--	--
Ave_Daily_Max_Sed_Bout_Min	--	--	--	-.407*	--
Step_Count	--	--	--	.369*	--

* Significant at $p < 0.05$ (two-tailed)
** Significant at $p < 0.01$ (two-tailed)

7.2.1.1 Conflicting Findings: Regression and Correlation

The results from the regression analysis corresponded to the results from the correlational analysis for results regarding both connectivity and self-reported distance from amenity spaces, however this same parallel was not found for objective distance from meeting rooms.

The result of the regression analysis suggests that as the objective distance from a workspace to a meeting room increases, the percent of time spent sedentary will similarly increase. While this finding was not refuted by the correlational analysis, this finding was also not echoed in the correlational analysis. In fact, the correlational analyses did not find any significant results with respect to objectively measured distances from meeting rooms. So while the regression analysis suggests that an increase in objective distance from meeting room will result in a similar increase in sedentary behavior, this was not confirmed in the correlational analysis.

While there were no significant correlations with respect to *meeting rooms*, several significant correlations were found between distances from other amenity spaces (like coffee/break area, printer) and sedentary behavior variables. In general the correlational findings suggest that as distance from various amenity spaces increases, sedentary time decreases. This general trend is contrary to the regression finding regarding objective distance from meeting rooms, which suggest that as distance from meeting rooms increases, sedentary time also increases. Therefore wile the majority of the data from this study supports a general conclusion, this anomaly provided mixed support that distance from various amenity spaces influence sedentary behavior. For this reason future research is needed to more fully understand the relationship between distance from amenity spaces and sedentary behavior.

One explanation offered by this author for the divergent findings from this study is the possibility that the finding regarding a positive relationship between objective distance from meeting room and sedentary behavior may have been a statistical anomaly. One explanation for this is as follows: The findings regarding connectivity and self-reported distance from coffee/break area are consistent for both the correlation and regression analysis. This suggests that the inverse relationship between these two variables was indeed observed in the sample, and that it was not a happenstance statistical conclusion/interpretation. The findings from the regression analysis regarding objectively measured distance from meeting spaces, however, were not echoed in the correlation analysis. While conflicting results were not found in the correlational analysis, as there were not any significant correlations with objective distance from meeting spaces, this suggests that the relationship observed in the regression analysis may have been a statistical fluke that does not necessarily represent the existing relationship.

With these considerations in mind, Hypothesis 1 was not supported by the findings of the correlational analysis, and instead an inverse relationship was found. The trends indicate that individual whose workstations are closer to amenity spaces (and in particular coffee/break areas) spend a greater percent of time sedentary and less in light and moderate physical activity, take less steps per day, and have longer lengths of individual sedentary periods. So individuals whose workstations are further away from amenity spaces tend to engage in less sedentary behavior.

One possible explanation for this relationship is that the number of times that individuals go and get coffee or visit the break area does not change depending on whether they are closer to or further away from these spaces. In other words, a person would likely visit the coffee area/get coffee the same number of times per day regardless of whether their workspace was close to or far from the coffee/break area. A person would not get coffee more times in a day just because their workspace was closer to the coffee area. Thus, the individuals whose workspaces are relatively further from the coffee/break area will travel further, and spend more time in light or moderate physical activity when they do travel to these spaces than the individual whose workspace was closer.

7.2.2 Hypothesis 2: Connectivity

This study found consistent and significant relationships between connectivity and several measures of sedentary behavior, detailed below in Table 67, and all relationships indicate an inverse relationship between connectivity and sedentary behaviors (or positive relationship with physical activity).

Table 67
Pearson Correlations Between Connectivity and Sedentary Behavior Variables

	Connectivity_Visibility
Ave_Legth_Sed_Bout_Sec	--
Max_Length_Sed_Bout_Min	--
Daily_Ave_Sed_Bout_Min	-.431**
Toal_Sed_Breaks	--
Percent_Sedentary	-.512**
Percent_Light	.511**
Percent_Moderate	.399*
Percent_Vigorous	--
Ave_Daily_Max_Sed_Bout_Min	-.330*
Step_Count	.495**

* Significant at $p < 0.05$ (two-tailed)
** Significant at $p < 0.01$ (two-tailed)

Hypothesis 2 was supported by the findings of this study. Office workers were found to have more sedentary behaviors when their workstations have low visibility than those whose workstations have high visibility. The key findings are that individuals whose workstations have low visibility:

- Engage in longer bouts of sitting
- Spend a greater amount of time (hours), on average, in sedentary bouts
- Spend a greater proportion of their time (%) engaged in sedentary behaviors
- Spend a smaller proportion of their time (%) engaged in light and moderate physical activity
- Have lower total step counts

Connectivity, which is a measure of the visibility of a space, was shown to have positive associations with several measures of sedentary behavior. If a space has high visibility that means that one is able to see many other spaces from within it, and if a space has low visibility it means that it is generally enclosed, and therefore not many spaces can be seen from within it. Examples of spaces with high visibility include open-office plans with no partitions, low partitions (~3 feet), and shared offices. Examples of spaces with low visibility include private offices and cubicles with full-height partitions (>5 feet).

The results suggest that when a workspace has high visibility, or is can be seen from many other spaces in the office, the individual in that workspace will engage in less sedentary behavior, more light and moderate physical activity, and take more steps per day.

One explanation offered by this author for this trend is the influence of social networks in the office. Individuals whose workspaces are visible from many other spaces in the office may be drawn to or attracted by other individuals or activities occurring in the office, encouraging/enticing/motivating them to stand up and/or walk (even if only a few steps) to engage with the event or person. These sorts of interruptions would reduce overall sedentary time, as well as interrupt periods of prolonged sitting.

7.2.3 Hypothesis 3: Integration

The fact that measures of integration were not significantly correlated to any measures of sedentary behavior suggests that it exerts less of an influence on sedentary behavior patterns than other spatial variables. While visibility (connectivity) was significantly correlated with several sedentary behavior outcomes, integration (a measure of the number of turns required to reach each space in the network) was not correlated with any measures. This suggests that, while integration can be a successful way to measure foot traffic and the possibility of encounters in a certain space, the fact that spaces are well integrated (and therefore theoretically have higher foot traffic) does not bear on the sedentary behavior patterns of the occupants. The conclusion that can be drawn from this finding is that workspaces with high "movement potential" do not necessarily draw occupants out of their seats, and instead these are spaces that have large amounts of extraneous movement.

The results from this study do not provide any support Hypothesis 3, that office workers have more sedentary behaviors when their workstations have low overall integration. The results from this study indicate that there is no relationship between sedentary behaviors and workstation integration.

The lack of any significant findings regarding integration was surprising to this author. The Space Syntax measure of integration has been shown to effectively predict movement patterns and points of interaction. It would be assumed that workstations that have a high integration value (which indicates a high volume of traffic/circulation passing by) would be interrupted/drawn to engage with others more frequently, and therefore stand up and reduce the amount of time they spend sedentary.

One possible explanation for the lack of significant findings regarding integration is that the individual workstations themselves were measured for integration, and not the surrounding circulation paths. So whereas an office may be located adjacent to a high-traffic (high integration) circulation path, the high integration of the circulation area was not necessarily reflected in the measure of the individual office. This can be seen in figure 48, below; the areas shaded in yellow and red indicate high integration, while the green and blue areas indicate lower integration. In this example, the cubicle identified by the red box is located adjacent to a circulation route that has very high integration (yellow). However, due to the cubicle wall the integration observed within the boundaries of the workspace are significantly lower (blue). This separation between workspaces and circulation was included in the integration analysis even if partitions were only half-height, and able to be seen over. So while some individuals may have been directly exposed to areas of high integration, the measure of integration taken within their workstation did not reflect this. Thus, some of the variance in sedentary behavior that might be attributed to exposure to areas of high integration was not accounted for by measures of workspace integration, as readings were only taken within the boundaries of the workspace.

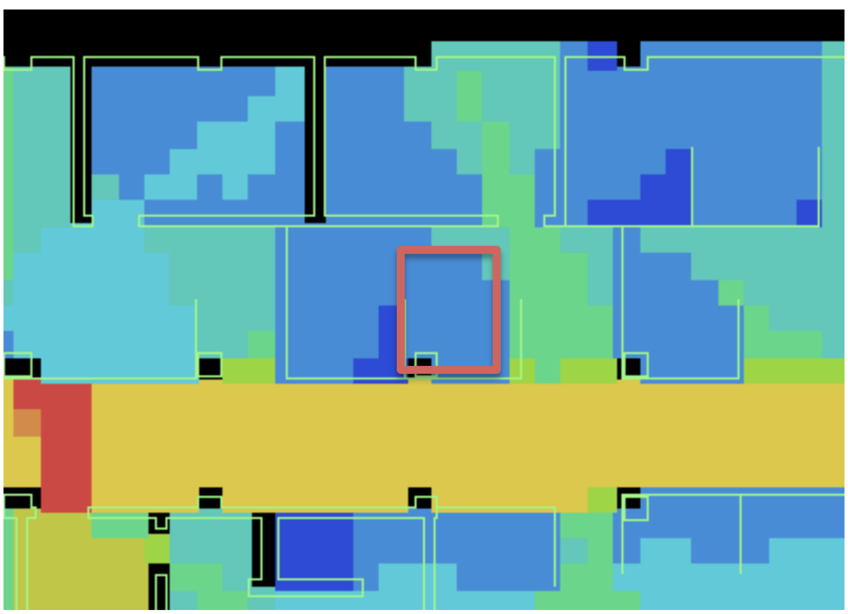

Figure 48: Integration Heat Map

This highlights a limitation of the Space Syntax methodology that future studies should aim to address.

7.2.4 Hypothesis 4: WLQ

Hypothesis 4 was not supported by the findings of this study. The only significant finding regarding presenteeism was that individuals who reported more presenteeism (i.e. greater loss in productivity) spent a greater percentage of time in vigorous physical activity.

The positive relationship between presenteeism (WLQ Productivity Loss Score) and percent of time spent in vigorous physical activity is quite a perplexing finding. This result suggests that as percent of time spent in vigorous physical activity increases, the productivity loss score (amount of reduced ability to perform work) also increases. This suggests that individuals who engage in more vigorous physical activity during the workday also have more employee presenteeism, or, conversely, that individuals who engage in more physical activity during the workday have a decreased ability to perform work compared to those who engage in less vigorous physical activity during the workday. This finding, although statistically significant, is based on a small sample size as very few individuals recorded any vigorous physical activity at all.

Previous studies have found a positive relationship between presenteeism and sedentary behavior, or that individuals who spent more time sedentary reported a greater loss in productivity. This could be conversely extended to a further hypothesis that individuals who spend less time in light, moderate, and vigorous physical activity (the inverse of more sedentary time) would also report a greater loss in productivity. This study found the opposite with respect to vigorous physical activity, with individuals spending more time in vigorous physical activity reporting a greater loss in productivity. This finding is not necessarily counterintuitive, however, as this study did not find any relationships with sedentary behavior (and so does not contradict previous findings), only with respect to vigorous activity. One possible explanation for this is that only a minority of individuals recorded any vigorous physical activity at all throughout the five-day wear period. Perhaps the individuals who did engage in vigorous physical activity while at work have more physically demanding jobs, and therefore their answers to the WLQ questions may have been skewed upwards simply due to job tasks, and not individual physical ability or the influence of sedentary behavior.

Table 68
Pearson Correlations Between WLQ and Sedentary Behavior Variables

	Percent_Vigorous
WLQ Productivity Loss Score	.361*
Time Management Subscale	.403*
Physical Demands Subscale	--
Mental Interpersonal Subscale	.468**
Output Subscale	--

* Significant at $p < 0.05$ (two-tailed)
** Significant at $p < 0.01$ (two-tailed)

The results of this study do not support H4, and instead suggest that employee presenteeism is positively associated with occupational vigorous physical activity. The results from this study suggest that, while there is a weak relationship between presenteeism and vigorous physical activity, there is no relationship between presenteeism and sedentary time.

7.3 Key Space Parameters that influence Sedentary Behavior

The key findings from this study are that in order to reduce sedentary time in the workplace, distance from amenity spaces must be increased while at the same time increasing the connectivity of workspaces.

These results are logically related, considering correlations between connectivity and distance measures. In particular, this study found a correlation between connectivity and self-reported distance from printer/copier ($r=.278$, $p=.048$)and self-reported distance from meeting room ($r=.352$, $p=.045$). This suggests that as distance from certain amenity spaces increases (which alone correlates to reductions in sedentary time) connectivity also increases, therefore further reducing sedentary time.

Following the results of the regression and correlational analysis, connectivity and self-reported distance from coffee/break area were found to be the spatial factors that influence the percent of time spent in sedentary behaviors. Distance from coffee/break area was found to have a negative predictive effect on sedentary behavior, meaning that as distance from coffee/break area increased it would be expected that the percent of time spent sedentary would decrease.

The results regarding connectivity were consistent in both the correlation and regression analysis – suggesting that individuals who work in workstations with higher connectivity (visibility) will engage in less sedentary behavior than those who work in workstations with low connectivity (visibility).

7.4 Congruence/Comparison with Previous Literature

7.4.1 Distance Measures

The general findings from the correlational analysis suggest a different relationship between distance from amenity spaces and sedentary behavior than that which was found in Hua and Yang (2013), who found that individuals whose workstations were closer to amenity spaces took more steps per day. However results from the regression analysis regarding objective distance from meeting room agree with Hua and Yang's findings, and suggest that distance from meeting spaces significantly predicts the percent of time spent in sedentary behaviors; as distance from meeting spaces increases the amount of time spent sedentary will similarly increase.

7.4.2 Connectivity

Very little previous research has explored the relationship between connectivity and sedentary behavior. While it has been shown that when buildings have greater connectivity individuals tend to walk more and sit less, Rashid et al (2006) found no relationship between connectivity and sedentary work. Duncan, however, found several relationships between connectivity and measures of sedentary behavior, however the results were mixed and did not show a general trend. This study found consistent and significant relationships between connectivity and several measures of sedentary behavior and all relationships indicate an inverse relationship between connectivity and sedentary behaviors (or positive relationship with physical activity).

CHAPTER 8: CONCLUSION & DESIGN RECOMMENDATIONS

The results from this study indicate that distance from amenity spaces and the space syntax measure of connectivity have significant impacts on the amount of time office workers spend sedentary. Consistent relationships were found indicating that as the distance between a workspace and various amenity spaces increases, the amount of time the individual occupying that workspace will spend sedentary will decrease. Conversely, individuals whose workstations are close to amenity spaces will spend a greater amount of their time in sedentary behaviors.

As was mentioned in the discussion, Consistent relationships were found with both self-reported and objectively measured distances, however self-reported distances were more frequently significantly related to sedentary behavior variables than were objectively-measured distances. For this reason, the significant relationships regarding self-reported distances are summarized below, as they have been shown to most strongly predict sedentary behaviors.

As the self-reported distance from coffee/break area increased:

- Percent of time spent sedentary decreased
- The average length of a sedentary period decreased
- The amount of time spent in sedentary behavior per day decreased
- Step counts increased
- Time spent in light and moderate physical activity increased

As the self-reported distance from printer/copier increased:

- The number of breaks in sedentary time increased
- Time spent in light physical activity increased
- Time spent sedentary decreased

As the self-reported distance from mail room increased:

- The average amount of time spent sedentary decreased
- The percent of time spent in moderate physical activity increased

It was also consistently shown that as the connectivity of a workspace increases (i.e. as the number of other spaces that are visible from within the workspace increases), the amount of time the individual in that workspace spends sedentary would decrease. This suggests that when individuals can see many other spaces in the office, and similarly when many other spaces are able to see into the workspace of that individual, they will spend less time sedentary.

As connectivity increased (visibility increased):

- The average amount of time spent engaged in sedentary behaviors decreased
- The percent of time spent in sedentary behaviors decreased
- Step counts increased
- Percent of time spent in light and moderate physical activity increased

8.1 Design Recommendations

Given the findings of this study, design recommendations were developed to encourage active behaviors in office workers. Care should be taken when designing layouts to increase the connectivity of workspaces, when the type of work being performed allows it. Increasing connectivity translates to increasing the visibility within the office. This can be accomplished using half-height instead of full-height cubicle partitions, employing glass as a partition material whenever possible, and organizing cubicles and offices so that they are able to have the most visual access to other spaces in the suite/floor.

In order to encourage individuals to reduce the length of their sedentary periods and reduce overall sedentary time, printers/copiers and coffee/break areas should not be widely distributed, and sharing of these amenity spaces between suites or floors is encouraged. This can be accomplished by providing a centralized coffee/break area that multiple suites/departments share, rather than providing a coffee/break area located within each individual suite/department. Printers/copiers should also be centralized and not distributed; individuals should not have printers in their private offices/cubicles. Of all of the amenity spaces surveyed, individuals reported making the most trips per day to the printer (average of 5.37 times/day), and so increasing the distance between workspaces and printers could have a significant impact on both the length of sedentary bouts and the total amount of time spent sedentary.

8.1.1 Design Recommendations: Centralized Amenity Spaces in Workplace

Because it was found that individuals whose workstations are further from amenity spaces engage in less sedentary behaviors, it is not suggested that designers attempt to minimize the distance between workstations and these amenity spaces; instead, it is recommended that amenity spaces are located further from workstations. This recommendation conflicts with the general goal of convenience in spatial design – where the aim is to distribute amenity spaces such that distances are short and resulting trips to them are quick. This study suggests that this approach – of bringing the amenities to the people – does not have beneficial consequences for sedentary behavior. Instead, when individuals must travel further to reach the amenities – when the people are brought to the amenities – this results in an increase in light and moderate physical activity and a decrease in the amount of time spent sedentary for the office workers. Keeping this result in mind, it is recommended that instead of distributing amenity spaces (e.g. one small coffee area for each of several suites on a floor), these spaces should be located in centralized areas, common to several independent suites and perhaps even floors. This would allow for a larger, consolidated amenity space to be provided, rather than small satellite spaces within each suite.

This recommendation has several implications, other than those related to sedentary behavior. First, it would simplify maintenance, as only one or a few common spaces would need to be maintained rather than a number of small independent spaces. Second, it would allow for cross-departmental interactions. By drawing individuals out of their respective suites, it creates an opportunity for interaction that might not otherwise present itself if individuals are limited to visiting amenity spaces located within their suites or on their floors. Finally, it would allow for higher quality amenities to be provided; instead of purchasing several lower-quality and cheaper devices for each individual suite, a single device of high quality can be purchased and shared between groups.

8.1.2 Design Recommendations: Increase Visual Access of Workstations

The findings regarding connectivity have several implications for the design of office space. The results suggest that when workers are able to see many other spaces in the office from within their office (or, conversely, that many spaces within the office are able to see into their workspace), the individual occupying that workspace will engage in less sedentary behaviors. This implies that the visibility of individual workstations should be maximized in order to reduce the amount of time the occupant spends sedentary. This can be achieved in several ways.

There are only a few ways to increase the visibility of private, walled offices, however one method is to use glass paneling or windows instead of walls and doors. This would remove the visibility barrier between adjacent circulation spaces and the private office, and would allow the individual occupying the space to see more spaces within the office. This would, hypothetically, increase the chances that the individual would be drawn to engage in some sort of activity or conversation, and therefore cause an interruption in sedentary behavior.

Open-plan cubicle workspaces are much more flexible, and lend themselves to increased visibility much more easily than do private offices. There are several ways to increase the visibility of a cubicle workstation, including removing one or more partitions/walls, reducing the height of the partitions on one or more sides of the workstation, and changing the material of the partition to glass on one or more sides of the workstation.

The effect of lowering a full-height partition to a half-height partition on connectivity can be seen below, in figures 49 and 50. In figure 49, there is a full-height partition enclosing the office indicated by the red square. In this scenario, the connectivity of the workspace is 157. If this partition were to be removed, or turned into a half-height partition, the connectivity map would appear as it does in figure 50. In this scenario, the same workspace (indicated by the red square) would have a connectivity rating of 402. In this way, removing or reducing the height of a single partition can have significant effects on connectivity.

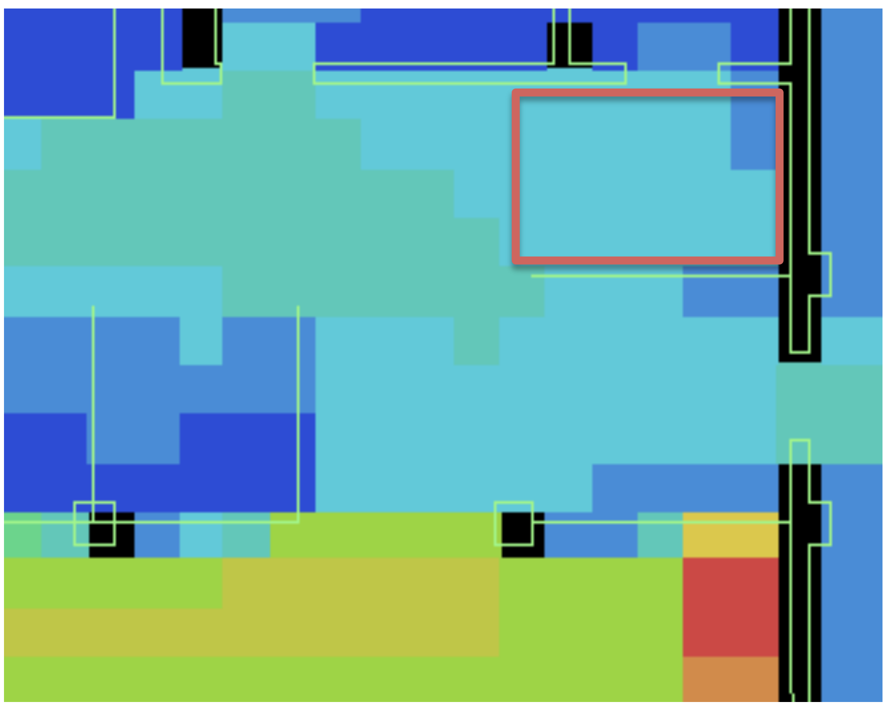

Figure 49: *Connectivity Heat Map, Identified Workspace with Full-Height Partition (connectivity rating 157)*

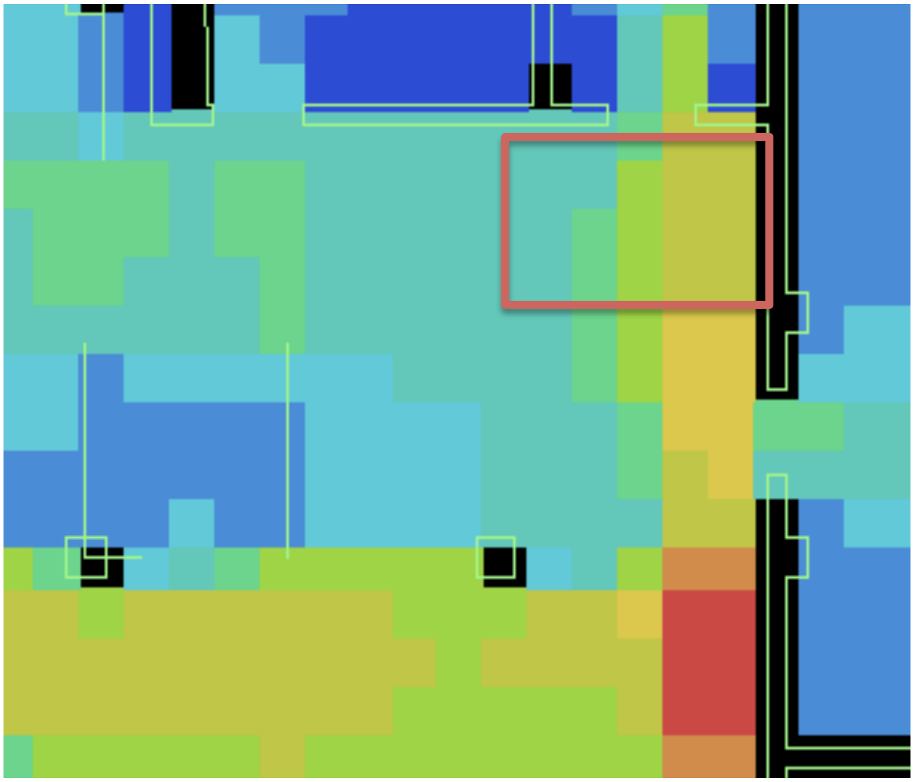

Figure 50: *Connectivity Heat Map, Identified Workspace with Half-Height Partition (connectivity rating 402)*

More significant changes could include shifting employees from individual to shared workspaces; this could be achieved by removing a single partition between two adjacent cubicles, making a single cubicle of double the size for both employees to work in.

The most significant recommendation, and one that is perhaps easiest to implement, is to reduce the height of full-height partitions so that they no longer impede vision (e.g. ~3 feet high). Examples of this can be seen in Figures 51-54. As many cubicles are modular in design, this change could require only very little effort. With this change individuals would still have private cubicles, however they would now be exposed on one or more sides instead of being fully enclosed.

Figures 51-54: Cubicle Designs

8.1.3 Design Recommendations and Productivity

The previous recommendations, aimed to reduce sedentary behaviors, may be at odds with other physical environment design features demanded by an organization's needs. For example if employees need a significant amount of privacy/security for the type of work they are performing, then low partitions may not be a feasible option. For situations where this is the case, we recommend attempting to manipulate the location of amenity spaces (H.1.) instead.

So the issue arises of how to achieve sedentary behavior goals while still maintaining the productivity of the workspace. This study attempted to identify a relationship between productivity (measured by the WLQ Productivity Loss Score) and sedentary behavior, in order to make an argument for taking steps towards reducing sedentary behavior, however no significant relationships were identified using the measures from this study.

This does not necessarily mean that there is no relationship between sedentary behavior and productivity. The proven relationship between sedentary behavior and negative health consequences means that the sedentary behaviors of office workers indeed do influence their health. It is very likely that these health impacts translate to increased healthcare costs, increased absenteeism, and increased turnover, each of which has implications for the bottom line.

So in this way sedentary behavior indeed does affect companies' financial bottom line, even if no relationships with presenteeism were found in this study.

So the critical issues that might be raised regarding the previous recommendations to increase the connectivity of office spaces relate to visual and acoustic privacy; increasing connectivity by reducing the height of partitions or removing partitions altogether would necessarily chance the acoustical and visual privacy of the workspace. These implications could be seen as having a negative impact on productivity, and so the following strategies have been proposed to address the privacy issues that might arise from following the previous recommendations.

Visual and Auditory – Providing additional 'privacy' spaces, such as small meeting rooms or small private offices, where any individual in the office can visit when they need privacy would allow individuals to have access to the privacy they need when they need it while keeping the connectivity of their personal workspace high. These spaces can be used to make phone calls, browse confidential information, or other activities requiring a large amount of privacy.

Auditory – For spaces where noise is an issue, another option would be to use sound masking technology in the space so that conversations are not be intelligible in surrounding workstations. Sound masking is the addition of sound created by special digital generators to an area to reduce distractions or provide confidentiality where needed.

Visual – In spaces where visual privacy is an issue, for example where confidentiality is needed, it may be possible to use privacy screen protectors. These devices are small pieces of film that are attached to a screen. When viewed from an angle, these turn black and prevent individuals from seeing the screen. This can be seen in the images, below, with a product from 3M.

Figure 55: Privacy Screen Protector

Centralizing amenity spaces may also have implications for productivity. Allowing for cross-departmental interaction may increase the ability of employees to perform work by increasing their connection networks. This will support the ability to perform work by allowing individuals to know where the information they are looking for in a n organization is. Further, increasing personal connections with coworkers may have implications for employee satisfaction. Individuals who have friends at work, it would be assumed, are more satisfied. This means that central amenity spaces have implications for a positive workplace culture, and may also influence satisfaction, which in turn influence employee turnover. This

8.2 Closing Comments

With results such as the ones that were found in this study, it might be possible to begin developing design recommendations for work environments to better support the health behaviors of office workers. This could have significant implications for both health as well as organizational productivity. While this study did not find any relationships with presenteeism, given the proven negative links between sedentary behavior and various health outcomes reducing sedentary behavior could reduce healthcare costs, absenteeism, and employee turnover, each of which have financial implications.

While some work is now becoming mobile, and some forms of telecommuting (eg. email) are becoming popular, much work remains in traditional office settings. The individuals in this study were sedentary for an average of 5 hours 8 minutes per day, or 25 hours 40 minutes per week – and that is only in the work setting, during the workweek. This suggests that the office environment would be a prime location to begin interventions to reduce sedentary behavior, as this could have a significant impact on the overall amount of time spent sedentary by office workers.

These findings further suggest that office spaces urgently need to be redesigned, however appropriate and effective interventions must first be identified. This study has found that interventions designed to address the visibility of workstations, as well as the arrangement of amenity spaces (particularly meeting rooms and coffee/break areas) might be well suited interventions to influence sedentary behavior at the physical environment level.

CHAPTER 9: LIMITATIONS

This study has several limitations, including the sample size, location, site selection, type of work, workplace culture, statistical analyses, and data cleaning, which also lead to my suggestions for future studies on this topic.

Sample Size: One of the main limitations of this study is the limited sample size, with a total of 40 individuals wearing accelerometers and a total of 58 individuals completing the survey. Future studies evaluating the relationship between spatial variables and physical activity should aim to include a larger sample size in order to provide more statistical power. Population has a lower BMI than average Americans.

Sample Health: The individuals in this study had, on average, a lower BMI than the U.S. average, and fewer individuals were obese. Thus, this may have been a healthier population and may not be representative of the average American, skewing results. Future studies should aim to include a large and representative sample of participants that more closely reflect the health of Americans in general.

Location: Both study sites are location in a small city, and this could pose problems when generalizing findings to larger urban areas. Future studies should aim to include both urban and rural sites.

Site Selection: Only two sites were included in this study. Although the buildings of study were incredibly diverse, with distinct features observed not only between buildings but also within buildings (floors, suites have very different layouts within each building), the small number of buildings was a limitation. Future studies should aim to include a larger variety of building types and building sizes.

Type of work: The buildings of study were chosen due to the administrative nature of the work being performed within them. The precise roles of each of the participants, however, varied significantly; some participants were administrative assistants while others were specialized staff members, and even others were technicians or faculty. This variability in job roles may have influenced the findings from this study. Future studies should aim to sample a more homogenous group of positions, considering job demands may significantly influence sedentary behavior patterns.

Workplace Culture: The workplace culture was not evaluated in this study. The structure of an organization (e.g. hierarchy) can influence behavior patterns, and so future studies should aim to gather information about how workplace culture affects occupants, even if this is done qualitatively through interviews.

Statistical analyses: Due to the timeframe of this study, further statistical analysis was not possible. The objective sedentary behavior data gathered through accelerometry was not analyzed for patterns (e.g. morning vs. afternoon). The data collected through this study will be made available for future analysis.

Data Cleaning: Data was processed according to the most up-to-date recommendations found in the peer-reviewed literature. Most studies evaluating sedentary behavior with accelerometers do not report their data cleaning methods, and this is a severe limitation of the literature. Space syntax methodologies for evaluating cubicle layouts are not well developed, and there is no standardized method for evaluating cubicle partitions of different heights. Future studies should report in detail the methods they used for data analysis.

APPENDIX A

Workplace Physical Activities Survey

The purpose of this survey is to assess the effects of building spatial design on the sedentary behavior of occupants. The following survey should take approximately 15 minutes to complete. We assure you that your answers will be treated in the strictest of confidentiality.

SECTION I. Work related Physical Activity

1. During the **last 7 days**, how many days did you do **vigorous** physical activities (at least 10 minutes at a time) **as part of your work**?

> **Vigorous** activities make you breathe much harder than normal. These may include things like heavy lifting, digging, heavy construction work, or climbing up stairs. Work includes paid and unpaid work as well as course work. Include all jobs and volunteer work.

__________days per week. *[If respondent answers 0, skip to Question 3]*
__________don't know/not sure. *[Skip to Question 3]*
__________not applicable. *[Skip to Question 3]*

2. During the **last 7 days,** how much time **on average** did you spend on doing **vigorous** physical activities **as part of your work**?

__________hours per day.
__________minutes per day.
__________don't know/not sure.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities (at least 10 minutes at a time) **as part of your work**?

> **Moderate** physical activities make you breathe somewhat harder than normal and may include activities like carrying light loads. Do not include walking. Work includes paid and unpaid work as well as course work. Include all jobs.

__________days per week. *[If respondent answers 0, skip to Question 5]*
__________don't know/not sure. *[Skip to Question 5]*
__________not applicable. *[Skip to Question 5]*

4. During the **last 7 days,** how much time **on average** did you spend on doing **moderate** physical activities **as part of your work**?"

__________hours per day.
__________minutes per day.
__________don't know/not sure.

5. During the **last 7 days**, how many days did you **walk as part of your work** (at least 10 minutes at a time)?

> Please do NOT count any walking you did to travel to or from work.

__________days per week. *[If respondent answers 0, skip to Question 7]*
__________don't know/not sure. *[Skip to Question 7]*
__________not applicable. *[Skip to Question 7]*

6. During the **last 7 days**, how much time **on average** did you spend on **walking as part of your work**?

__________hours per day.
__________minutes per day.
__________don't know/not sure.

7. During the **last 7 days**, how much time **on average** did you spend **sitting at work**?

__________hours per day.
__________minutes per day.
__________don't know/not sure.

8. During the **last 7 days**, how much time **on average** did you spend **standing at work**?

_________hours per day.
_________minutes per day.
_________don't know/not sure.

SECTION II. Satisfaction

1. Please indicate, to what extent do you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
How would you rate your satisfaction with your job?	☐	☐	☐	☐	☐
How satisfied are you with the spatial environment of your workplace?	☐	☐	☐	☐	☐
Overall, does the spatial environment support your ability to get your job done?	☐	☐	☐	☐	☐

2. How frequently do you experience the following feelings at work?

	Always	Daily	Several times/week	Seldom	Never
Unusual fatigue	☐	☐	☐	☐	☐
Sleepiness	☐	☐	☐	☐	☐
Feelings of stress	☐	☐	☐	☐	☐
Irritability	☐	☐	☐	☐	☐
Headaches	☐	☐	☐	☐	☐
In good mood	☐	☐	☐	☐	☐

SECTION III. Staircases and Elevators

1. How often do you walk the stair during a typical workday? _________times; a total of _________stories.

2. Please indicate, to what extent do you agree or disagree with the following statements according to your experience in your building.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The staircase entrance(s) are visible from where I enter the building.	☐	☐	☐	☐	☐
The elevator(s) are visible from where I enter the building.	☐	☐	☐	☐	☐
The staircase(s) are easily accessible from my office/cubicle.	☐	☐	☐	☐	☐
The elevator(s) are easily accessible from my office/cubicle.	☐	☐	☐	☐	☐
The elevator waiting time is long.	☐	☐	☐	☐	☐
The staircase(s) are safe to walk.	☐	☐	☐	☐	☐
The staircase(s) look pleasant.	☐	☐	☐	☐	☐
I talk to colleagues often when I walk stairs.	☐	☐	☐	☐	☐
The staircase is located along the primary path of my travel.	☐	☐	☐	☐	☐
The staircase entrance(s) are visible from elevator waiting area.	☐	☐	☐	☐	☐
The stair entry door(s) exist.	☐	☐	☐	☐	☐
The staircase is well maintained.	☐	☐	☐	☐	☐
The stair entry door(s) are often held open.	☐	☐	☐	☐	☐
I am comfortable with the height of step.	☐	☐	☐	☐	☐
I am comfortable with the temperature in staircase(s).	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There is natural daylight in staircase.	☐	☐	☐	☐	☐
Daylight in the staircase encourages me to use stairs.	☐	☐	☐	☐	☐
The staircase is wide enough for short conversations to take place.	☐	☐	☐	☐	☐
The staircase is clean.	☐	☐	☐	☐	☐
I have short conversations with my colleagues when I walk stairs.	☐	☐	☐	☐	☐

3. What is your first choice to go up/down floors?

☐Elevators
☐Stairs
☐Depends on the number of floors of a trip. Please specify_________floors
☐Other. Please specify___________

4. What is the main influence on stair use?

☐Direction of travel (whether up or down)
☐Time-related pressure from work
☐Crowdedness of elevators
☐Other. Please specify__________________________
☐Number of floors to travel
☐Time spent waiting for elevators
☐Speed of elevators

5. What is the main influence on choosing elevator?

☐Convenience
☐Habit
☐Carrying heavy things
☐The perception of not being fit enough to climb stairs
☐The perception that stairs are too far to reach the destination
☐Other. Please specify__________________________
☐To avoid getting sweaty or out of breathe
☐Laziness
☐Injury or health problems

6. What are the factors that encourage you to walk stairs?

☐The look and feel of the stairs
☐Staircase lit by natural daylight
☐Motivated by friends/colleagues who I walk with
☐Other. Please specify___________________
☐Staircase close to building entrance
☐Motivating signage

7. Is there any signage encouraging walking or using staircase in your building? ☐Yes ☐No ☐Don't know

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
8. If yes, has it positively affected your decision to use stairs?	☐	☐	☐	☐	☐
9. Does the effect of signage last more than a month?	☐	☐	☐	☐	☐

SECTION IV. Layout Impact

1. Please indicate, to what extent do you agree or disagree with the following statements according to your experience in your building.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There is enough space in my office/cubicle to hold a face-to-face meeting.	☐	☐	☐	☐	☐
There is appropriate furniture (e.g., table, guest chair, power outlet, etc.) for meetings in my office/cubicle.	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
There are different-sized meeting rooms/spaces on the floor where I am working.	☐	☐	☐	☐	☐
The arrangement and furnishing of the meeting rooms/spaces supports meeting effectiveness.	☐	☐	☐	☐	☐

2. How many trips do you make to meeting spaces during a typical workday?

	0	1	2	3	4	5 or more
On **my floor**	☐	☐	☐	☐	☐	☐
On **other floors** in my building	☐	☐	☐	☐	☐	☐

3. How far from your office/cubicle is the meeting space you use most frequently?

On **my floor** ____________ feet

On **other floors** in my building ____________ floor(s) and ____________ feet

4. What are the main factors when you choose which meeting room to use if you have a choice? **Please rank the choices, using numbers 1 ~ 5** (or 1~6 if you choose to fill in the "Other" item).

_________ Room capacity
_________ Furniture
_________ Technology
_________ Distance to my office/cubicle
_________ Room with window(s)
_________ Other. Please specify ______________________

5. How many times do you usually go to the printing/copy area during a typical workday? __________times.

6. How far is the printing/copy area from your office/cubicle? _________floors and _________feet.

7. How many times do you dispatch (mail) documents or goods during a typical workday? __________times.

8. How far is the dispatch area (or mail room) from your office/cubicle?___________floors and _________feet.

9. How many trips do you usually make to a coffee room (or a break room) during a typical workday?________times.

10. How far is the coffee room (or a break room) from your office/cubicle?__________floors and_________feet.

11. How many times do you use restrooms on average during a typical workday?_________times.

12. How far is the closest restroom from your office/cubicle? _________floors and_________feet.

13. At work, is there a cafeteria or restaurant inside your building? ☐Yes ☐No

14. If yes, how many times do you go to the cafeteria or restaurant during a typical workday?_________times.

15. How far is the cafeteria or restaurant from your office/cubicle? _________floors and_________feet.

	Never	Seldom	Sometimes	Often	Always
16. How often do you take a walk during lunch break or other break time?	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
17. Do you think workplace technology (e.g., email, internet messengers, etc.) increases your sedentary behavior?	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
18. Do you prefer email or instant message to talking in person with your colleagues?	☐	☐	☐	☐	☐

SECTION VI. Personal Description

1. What is your gender?
   ☐Male
   ☐Female
2. What is your age?
   ☐18-24 ☐25-29 ☐30-34 ☐35-39 ☐40-44
   ☐45-49 ☐50-54 ☐55-59 ☐60-64 ☐ >65
3. What is your weight (in pounds)?
   ☐ <120 ☐120-140 ☐141-160 ☐161-180 ☐181-200
   ☐201-220 ☐221-240 ☐ >240
4. What is your BMI? ____________________________(Please refer to appendix.)
5. How do you describe your race/ethnicity?
   ☐White ☐Black or African American ☐Asian ☐Native Hawaiian or Pacific Islander
   ☐Hispanic ☐American Indian or Alaska Native ☐Other
6. How would you describe your position?
   ☐Faculty ☐Post Doc ☐Graduate student
   ☐Undergraduate student ☐Research staff ☐Administration/Support
   ☐Technician ☐Management ☐Other. Please specify _______________
7. What is your highest level of education?
   ☐Some high school or less ☐High school graduates ☐Attended some college
   ☐Associate degree ☐Bachelor's degree ☐Postgraduate degree
8. How do you rate your overall health?
   ☐Very good ☐Good ☐Fair ☐Poor ☐Very poor ☐Don't know
9. Do you feel you get as much exercise as you need?
   ☐As much as I need ☐Less than I need ☐Don't know
10. How many days per week do you achieve 30 min of moderate physical activity (e.g., walking for pleasure, jogging, bicycling, swimming or water aerobics, dancing, etc.)?
    ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐Don't know
11. How many days per week do you walk at least 10 min at a time?
    ☐0 ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐Don't know
12. How many hours do you work during **a typical workday**? ______________Hours.
13. How many hours do you work during **a typical week**? _________________Hours.
14. How many hours do you work in **this building** per week? ________________ Hours.
15. How long have you been working in this building? ___________Years and ____________months.
16. How long have you been working in the current office/cubicle? ___________Years and _________months.

Please hand the completed survey to the field team, or return
to William Higgins, Design and Environmental Analysis
Tel: 513-255-3310 Email: wch56@cornell.edu

Thank you very much for your participation!

This survey includes questions from the following sources, used with consent:

Work Limitations Questionnaire, © 1998, The Health Institute, Tufts Medical Center f/k/a New England Medical Center Hospitals, Inc.; Debra Lerner, Ph.D.; Benjamin Amick III, Ph.D.; and GlaxoWellcome, Inc. All Rights Reserved.

Hua, Y. & Yang, E. (2014). Building spatial layout that supports healthier behavior of office workers: A new performance mandate for sustainable buildings. *Work: A Journal of Prevention, Assessment, and Rehabilitation*. Vol.49(3), 373-380.

The International Physical Activity Questionnaire, 2005. Available at http://www.ipaq.ki.se/

Appendix

To use the table, find the appropriate height in the left-hand column labeled Height. Move across to a given weight (in pounds). The number at the top of the column is the BMI at that height and weight. Pounds have been rounded off.

BMI	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**
Height (inches)	**Body Weight (pounds)**																
58	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
59	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
60	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179
61	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
62	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
63	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
64	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
65	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
66	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
67	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
68	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
69	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
70	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
71	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
72	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
73	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
74	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
75	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279
76	156	164	172	180	189	197	205	213	221	230	238	246	254	263	271	279	287

BMI	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**
Height (inches)	**Body Weight (pounds)**																		
58	172	177	181	186	191	196	201	205	210	215	220	224	229	234	239	244	248	253	258
59	178	183	188	193	198	203	208	212	217	222	227	232	237	242	247	252	257	262	267
60	184	189	194	199	204	209	215	220	225	230	235	240	245	250	255	261	266	271	276
61	190	195	201	206	211	217	222	227	232	238	243	248	254	259	264	269	275	280	285
62	196	202	207	213	218	224	229	235	240	246	251	256	262	267	273	278	284	289	295
63	203	208	214	220	225	231	237	242	248	254	259	265	270	278	282	287	293	299	304
64	209	215	221	227	232	238	244	250	256	262	267	273	279	285	291	296	302	308	314
65	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324
66	223	229	235	241	247	253	260	266	272	278	284	291	297	303	309	315	322	328	334
67	230	236	242	249	255	261	268	274	280	287	293	299	306	312	319	325	331	338	344
68	236	243	249	256	262	269	276	282	289	295	302	308	315	322	328	335	341	348	354
69	243	250	257	263	270	277	284	291	297	304	311	318	324	331	338	345	351	358	365
70	250	257	264	271	278	285	292	299	306	313	320	327	334	341	348	355	362	369	376
71	257	265	272	279	286	293	301	308	315	322	329	338	343	351	358	365	372	379	386
72	265	272	279	287	294	302	309	316	324	331	338	346	353	361	368	375	383	390	397
73	272	280	288	295	302	310	318	325	333	340	348	355	363	371	378	386	393	401	408
74	280	287	295	303	311	319	326	334	342	350	358	365	373	381	389	396	404	412	420
75	287	295	303	311	319	327	335	343	351	359	367	375	383	391	399	407	415	423	431
76	295	304	312	320	328	336	344	353	361	369	377	385	394	402	410	418	426	435	443

APPENDIX B

Accelerometry

Berendsen et al (2014) evaluated three activity monitors (ActivPAL3 (AP), ActiGraphGT3X (AG), and CAM) in both free-living and controlled laboratory conditions, and found that while the AP and CAM were both able to correctly classify posture 100% of the time, the AG was only able to correctly classify posture 33.9% of the time. Correlations between accelerometer intensity and walking speed were 0.98 for ActivPAL3, 1.00 for ActiGraphGT3X and 0.98 for CAM.
These results indicate that the AG shows moderate to high reproducibility and high user friendliness, but low validity for posture allocation as much lying time is classified as non-wear time, and sitting and upright time are often mingled. Sitting behind a computer was classified as standing time 23.6% of the time. For this reason, posture classification was not used in this analysis.

A study by Kozey-Keadle et al (2012) identified the ActivPal as the only tool that is sensitive enough to detect reductions in sitting time; neither ActiGraph 100 nor 150 counts-per-minute thresholds, nor any of the questionnaires, were able to detect a significant difference in sedentary time.

Space Syntax

Duncan et al (2013) developed a self-report instrument to measure the Space Syntax constructs of connectivity, integration, proximity of co-workers, and visibility of co-workers – the Office

Environment and Sitting Scale (OFFESS). OFFESS scales were shown to have good levels of internal consistency, test-retest reliability and display some evidence of construct validity. Significant associations were observed between all scales and occupational sitting behavior. In the total sample, there were significant associations between the duration of sitting and proximity of co-workers, as well as with overall connectivity (open plan office types). Frequency of breaks in sitting was significantly associated with local connectivity, visibility of co-workers (open plan offices), and proximity of co-workers (private enclosed office types).

> *"Examples of the counter expected relationships include associations between frequency of breaks in sitting and local connectivity in open plan offices, sitting duration, break frequency and overall connectivity in private enclosed offices, and sitting duration and co-worker proximity in open plan offices."*

IPAQ

> *"The International Physical Activity Questionnaire (IPAQ) measures time spent sitting with demonstrated validity and reliability. A study on the reliability and validity of the IPAQ sitting question(s) reported good test–retest repeatability (Spearman rho values >0.7 in four country-level samples for the IPAQ short form sitting question), and acceptable validity against accelerometers. This measurement study concluded that the sitting question in the IPAQ short form was suitable for population-level surveillance studies." (Bauman et al., 2011)*

Although not statistically different from accelerometer derived sedentary time, the Total Sitting Questionnaire (from the IPAQ) was found to underestimate sedentary time by an average of 40.5 minutes, while the Domain-Specific Questionnaire overestimated sedentary time by an average of 176 minutes (Kozey-Keadle et al, 2012). These findings suggest that caution should be taken when using either of these measures, and that their upward or downward biases should be accounted for.

Correlations between total sitting and accelerometer counts/min <100 were significant for both long (r = .33) and short (r = .34) forms (Rosenberg et al, 2008).

WLQ

> *"[The WLQ] is one of the most commonly used questionnaires to evaluate at-work disability and productivity loss. It contains 25 items arranged under four subscales addressing four dimensions of job demands namely: time demands, physical demands, mental/interpersonal demands, and output demands. The time demands subscale contains five items on punctuality, pacing, and productivity. The physical demands subscale has six items covering static positioning, moving around, lifting, repetitive movements, posture, and use of tools. The mental or interpersonal demands subscale contains nine items that assess concentration and on-the-job social interactions. The output demands subscale contains five items determining the volume and quality of work" (Arumugam & Macdermid, 2013).*

Testing the WLQ with 25 items and 4 dimensions, Lerner et al. (2001) found that the WLQ demonstrated high reliability and validity.

> *"A systematic review of the psychometric properties of the WLQ-25 revealed that the scales have been assessed in various populations and have demonstrated acceptable levels of validity, reliability and responsiveness….. The internal consistency of the subscales ranges from 0.77 to*

0.97. Test-retest validity ranges from 0.69-0.80 for the four sub scales" (Arumugam & MacDermid, 2013).

Bibliography

Allaire, S. (2003). Measures of adult work disability: The Work Limitations Questionnaire (WLQ) and the Rheumatoid Arthritis Work Instability Scale (RA-WIS). Arthritis & Rheumatism, S85-S89.

Arumugam, V., & Macdermid, J. (2013). The Work Limitations Questionnaire (WLQ-25).*Journal of Physiotherapy,* 276-276.

Bafna, S. (2003). Space Syntax: A Brief Introduction to Its Logic and Analytical Techniques. *Environment & Behavior,* 17-29.

Bauman, A., Chau, J., Venugopal, K., Pratt, M., Bull, F. C., Craig, C. L., et al. (2011). The Descriptive Epidemiology of Sitting. American Journal of Preventive Medicine, 41(2), 228-235.

Berendsen, B., Hendriks, M., Meijer, K., Plasqui, G., Schaper, N., & Savelberg, H. (2014). Which activity monitor to use? Validity, reproducibility and user friendliness of three activity monitors. BMC Public Health.

Brown, H. E., Ryde, G. C., Gilson, N. D., Burton, N. W., & Brown, W. J. (2013). Objectively Measured Sedentary Behavior and Physical Activity in Office Employees. Journal of Occupational and Environmental Medicine, 55(8), 945-953.

Clark, B., Thorp, A., Winkler, E., Gardiner, P., Healy, G., Owen, N., et al. (2011). Validity of Self-Report Measures of Workplace Sitting Time and Breaks in Sitting Time. Medicine & Science in Sports & Exercise, 1.

Conn, V. S., Hafdahl, A. R., Cooper, P. S., Brown, L. M., & Lusk, S. L. (2009). Meta-Analysis of

Workplace Physical Activity Interventions. American Journal of Preventive Medicine, 37(4), 330-339.

Chau, J. Y., Owen, N., Brown, W. J., Bauman, A. E., Dunstan, D. W., Gilson, N. D., et al. (2010). Are workplace interventions to reduce sitting effective? A systematic review. Preventive Medicine,51(5), 352-356.

Chau, J. Y., Ploeg, H. P., Dunn, S., Kurko, J., & Bauman, A. E. (2011). A tool for measuring workers' sitting time by domain: the Workforce Sitting Questionnaire. British Journal of Sports Medicine, 45(15), 1216-1222.

Dishman, R. K., Oldenburg, B., O'Neal, H., & Shephard, R. J. (1998). Worksite physical activity interventions. American Journal of Preventive Medicine, 15(4), 344-361.

Dugdill, L., Brettle, A., Hulme, C., Mccluskey, S., & Long, A. (2008). Workplace physical activity interventions: a systematic review. International Journal of Workplace Health Management, 1(1), 20-40.

Duncan, M. J., Rashid, M., Vandelanotte, C., Cutumisu, N., & Plotnikoff, R. C. (2013). Development and reliability testing of a self-report instrument to measure the office layout as a correlate of occupational sitting. International Journal of Behavioral Nutrition and Physical Activity.

Dunstan, D., Kingwell, B., Larsen, R., Healy, G., Cerin, E., Hamilton, M., ... Owen, N. (2011). Breaking Up Prolonged Sitting Reduces Postprandial Glucose and Insulin Responses. Diabetes Care, 976-983.

Dunstan, D., Thorp, A., & Healy, G. (2011). Prolonged sitting: Is it a distinct coronary heart disease risk factor? Current Opinion in Cardiology, 26(5), 412-419.

Ekelund, U., Ward, H. A., Norat, T., Luan, J. a., May, A. M., Weiderpass, E., . . . Riboli, E. (2015). Physical activity and all-cause mortality across levels of overall and abdominal adiposity in European men and women: the European Prospective Investigation into Cancer and Nutrition Study (EPIC). *The American Journal of Clinical Nutrition, 101*(3), 613-621. doi: 10.3945/ajcn.114.100065

Evans, R. E., Fawole, H. O., Sheriff, S. A., Dall, P. M., Grant, P. M., & Ryan, C. G. (2012). Point-of-Choice Prompts to Reduce Sitting Time at Work. American Journal of Preventive Medicine, 43(3), 293-297.

Eves, F. F., & Webb, O. J. (2006). Worksite interventions to increase stair climbing; reasons for caution. Preventive Medicine, 43(1), 4-7.

Finch, E. (2007). The Health Impact Of Space Planning Policies In Relation To Walking And Exercise In The Workplace.Proceedings of Clima 2007 WellBeing Indoors, 1-8.

Force on Community Preventive Services. (2010). Recommendation For Use Of Point-of-Decision Prompts To Increase Stair Use In Communities. American Journal of Preventive Medicine, 38(2), S290-S291.

Gilson, N. D., Puig-Ribera, A., Mckenna, J., Brown, W. J., Burton, N. W., & Cooke, C. B. (2009). Do walking strategies to increase physical activity reduce reported sitting in workplaces: a randomized control trial. International Journal of Behavioral Nutrition and Physical Activity,6(1), 43.

Glanz, K. (2008). Health behavior and health education: Theory, research, and practice (3rd ed.). San Francisco: Jossey-Bass.

Hamilton, M. T., Healy, G. N., Dunstan, D. W., Zderic, T. W., & Owen, N. (2008). Too Little Exercise And Too Much Sitting: Inactivity Physiology And The Need For New Recommendations On Sedentary Behavior. Current Cardiovascular Risk Reports, 2(4), 292-298.

Jans, M. P., Proper, K. I., & Hildebrandt, V. H. (2007). Sedentary Behavior in Dutch Workers. American Journal of Preventive Medicine, 33(6), 450-454.

Kahn EB, Ramsey LT, Brownson RC, Heath GW, Howze EH, Powell KE, Stone EJ, Rajab MW, Corso P. The effectiveness of interventions to increase physical activity. A systematic review. Am J Prev Med. 2002 May;22(4 Suppl):73-107. Review. PubMed PMID: 11985936.

Kerr, J. (2000). Posters can prompt less active people to use the stairs. Journal of Epidemiology & Community Health,54(12), 942-943.

Kerr, J., Eves, F., & Carroll, D. (2001). Can Posters Prompt Stair Use in a Worksite Environment?. Journal of Occupational Health, 43(4), 205-207.

Klarqvist, B. (1993). A Space Syntax Glossary. *NORDISK ARKITEKTURFORSKNING*.

Kozey-Keadle, S., Libertine, A., Lyden, K., Staudenmayer, J., & Freedson, P. S. (2011). Validation of Wearable Monitors for Assessing Sedentary Behavior.Medicine & Science in Sports & Exercise,43(8), 1561-1567.

Kozey-Keadle, S., Libertine, A., Staudenmayer, J., & Freedson, P. (2012). The Feasibility of Reducing and Measuring Sedentary Time among Overweight, Non-Exercising Office Workers. Journal of Obesity, 2012, 1-10.

Kwak, L., Kremers, S., Baak, M. V., & Brug, J. (2007). A poster-based intervention to promote stair use in blue- and white-collar worksites. Preventive Medicine, 45(2-3), 177-181.

Lagersted-Olsen, J., Korshøj, M., Skotte, J., Carneiro, I. G., Søgaard, K., & Holtermann, A. (2013). Comparison of Objectively Measured and Self-reported Time Spent Sitting. International Journal of Sports Medicine, 35, 534-540.

Lerner, D., Amick, B., Rogers, W., Malspeis, S., Bungay, K., & Cynn, D. (2001). The Work Limitations Questionnaire. *Medical Care, 39*(1), 72-85.

Marshall, AL (2004). Challenges and opportunities for promoting physical activity in the workplace. Journal of Science and Medicine in Sport 7 [1): Supplement: 60-66.

Marshall, S. J., & Ramirez, E. (2011). Reducing Sedentary Behavior: A New Paradigm in Physical Activity Promotion.American Journal of Lifestyle Medicine,5(6), 518-530.

Moore, E., Richter, B., Patton, C., & Lear, S. (2006). Mapping Stairwell Accessibility in Vancouver's Downtown Core. Canadian Journal of Public Health / Revue Canadienne de Sante'e Publique, 97(2), 118-120.

Nicoll, G. (2007). Spatial Measures Associated with Stair Use. American Journal of Health Promotion, 21(4s), 346-352.

Nocon, M., Muller-Riemenschneider, F., Nitzschke, K., & Willich, S. N. (2010). Review Article: Increasing physical activity with point-of-choice prompts - a systematic review. Scandinavian Journal of Public Health, 38(6), 633-638.

Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too Much Sitting: The Population-Health Science of Sedentary Behavior. Exercise and Sport Sciences Reviews, 38(3), 105-113.

Owen, N., E. Leslie, J. Salmon and M.J. Fotheringham. Environmental determinants of physical activity and sedentary behavior. Exerc. Sport Sci. Rev., Vol. 28, No. 4, pp 153-158, 2000.

Owen, N., Sugiyama, T., Eakin, E. E., Gardiner, P. A., Tremblay, M. S., & Sallis, J. F. (2011). Adults' Sedentary Behavior: Determinants and Interventions. American Journal of Preventive Medicine, 41(2), 189-196. Retrieved January 26, 2014, from http://dx.doi.org/10.1016/j.amepre.2011.05.013

Penn, A. (2003). Space Syntax And Spatial Cognition: Or Why the Axial Line? *Environment & Behavior,* 30-65.

Plotnikoff, R. C., Mccargar, L. J., Wilson, P. M., & Loucaides, C. A. (2005). Efficacy of an E-mail Intervention for the Promotion of Physical Activity and Nutrition Behavior in the Workplace Context. American Journal of Health Promotion, 19(6), 422-439.

Proper, K. I., Singh, A. S., Mechelen, W. v., & Chinapaw, M. J. (2011). Sedentary Behaviors And Health Outcomes Among AdultsA Systematic Review Of Prospective Studies. American Journal of Preventive Medicine, 40(2), 174-182.

Rashid, M., Craig, D., & Zimring, C. (2006). Sedentary & Fleeting Activities & Their Spatial Correlates in Offices. Proceedings of the 37th Annual Conference of the Environmental Design Research Association, 37, 22-29.

Rhodes, R. E., Mark, R. S., & Temmel, C. P. (2012). Adult Sedentary Behavior: A Systematic Review. American Journal of Preventative Medicine, 42(3), e3-328. Retrieved January 26, 2014, from http://dx.doi.org/10.1016/j.amepre.2011.1

Rosenberg, Dori E., Bull, Fiona C., Marshall, Alison L., Sallis, James F., & Bauman, Adrian E. (2008) Assessment of sedentary behavior with the international physical activity questionnaire. The Journal of Physical Activity and Health (JPAH), 5(Supp 1), S30-S44.

Ruff, R. R., Rosenblum, R., Fischer, S., Meghani, H., Adamic, J., & Lee, K. K. (2013). Associations between building design, point-of-decision stair prompts, and stair use in urban worksites. Preventive Medicine.

Ryan, J., Lyon, K., Webb, O. J., Eves, F. F., & Ryan, C. G. (2011). Promoting physical activity in a low socioeconomic area: Results from an intervention targeting stair climbing. Preventive Medicine, 52(5), 352-354.

Sallis, J., Bauman, A., & Pratt, M. (1998). Environmental and policy interventions to promote physical activityaaThis work was prepared for the CIAR Conference on Physical Activity Promotion: An ACSM Specialty Conference. American Journal of Preventive Medicine, 379-397.

Sasaki, JE; John, D; Freedson, PS. (2011). Validation and Comparison of ActiGraph Activity Monitors

Schuna, J. M., Johnson, W. D., & Tudor-Locke, C. (2013). Adult self-reported and objectively monitored physical activity and sedentary behavior: NHANES 2005–2006. International Journal of Behavioral Nutrition and Physical Activity, 10(1), 126.

Seguin, R., Buchner, D., Liu, J., Allison, M., Manini, T., Wang, C., ... Lacroix, A. (2014). Sedentary Behavior and Mortality in Older Women. American Journal of Preventive Medicine, 46(2), 122-135.

Smith, L., Wardle, J., Fisher, A., Ambler, G., Hamer, M., Konstantatou, M., et al. (2013). Active buildings: modelling physical activity and movement in office buildings. An observational study protocol. BMJ Open, 3(11), e004103-e004103.

Swartz AM, Rote AE, Welch WA, Maeda H, Hart TL, Cho YI, et al. Prompts to Disrupt Sitting Time and Increase Physical Activity at Work, 2011–2012. Prev Chronic Dis 2014;11:130318. DOI: http://dx.doi.org/10.5888/pcd11.130318 .

Taylor, W. (2005). Transforming Work Breaks to Promote Health. American Journal of Preventive Medicine, 29(5), 461-465.

Thorp, A. A., Owen, N., Neuhaus, M., & Dunstan, D. W. (2011). Sedentary Behaviors and Subsequent Health Outcomes in Adults. American Journal of Preventive Medicine, 41(2), 207-215.

UCL Depthmap. (n.d.). Retrieved March 15, 2015, from http://www.spacesyntax.net/software/ucl-depthmap/

Walker N, Michaud K, Wolfe F. Work limitations among working persons with rheumatoid arthritis: results, reliability, and validity of the work limitations questionnaire in 836 patients. J Rheumatol 2005;32:1006–12.

Wijndaele, K., Bourdeaudhuij, I. D., Godino, J. G., Lynch, B. M., Griffin, S. J., Westgate, K., et al. (2014). Reliability and Validity of a Domain-Specific Last-7-Day Sedentary Time Questionnaire. Medicine & Science in Sports & Exercise, 1.

Zimring, C., Joseph, A., Nicoll, G. L., & Tsepas, S. (2005). Influences of building design and site design on physical activity. American Journal of Preventive Medicine, 28(2), 186-193.